SCIENTIFIC AMERICAN SUPPLEMENT No. 824

Scientific American Supplement, Vol. XXXII. No. 824
Scientific American, established 1845.

NEW YORK, OCTOBER 17, 1891.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

RAIN MAKERS IN INDIA.

EVERY country subject to drought has its own peculiar method of supplicating for rain, and that in vogue in Kumaon in Northern India is not the least curious of them. Last winter the season was a very dry one in Kumaon, and consequently there was a failure of the crops, with great scarcity in the district. With the exception of a few showers, there were no winter rains, and that in a country where the population is almost wholly dependent upon grain as a means of subsistence meant a famine and starvation. In consequence of the drought a Hindoo fakir imposed a penance upon himself, and was suspended by his feet from a wooden beam. In this position he was swung backward and forward for a considerable time by means of a rope attached to his body and pulled by a fellow saint. Both men were plentifully bedaubed with cow-dung and ashes, and, save for a small cloth round the waist, were *minus* all clothing. In such a case, should rain fall within reasonable time after the penance, the fakir takes the entire credit for the relief to himself, and rises immensely in the estimation of the simple and credulous cultivator of the soil. Our illustration is from the *Graphic*, London.

RAIN MAKERS IN THE UNITED STATES.

AT the instance of the Hon. Charles B. Farwell, Senator from Illinois, an appropriation of $10,000 was made by the last Congress for experimental purposes relating to the artificial production of rain by firing explosives.

Senator Farwell has given an amusing account of how the appropriation was secured and his reasons for urging it. He makes no pretensions as a scientific man; he never, like Espy and others, made a complete study of the meteorologic laws and phenomena, but he learned that in the high regions above the earth there were air currents charged with moisture, and became impressed with the thought that by means of a sufficient number of first-class bangings the said moisture might be condensed and precipitated as rain. "This idea," he said, "is old enough. I've been convinced of its practicability for twenty years, and probably other people have. It's just a question of applying what you know. Everybody knows there's a certain amount of moisture in the air all the time. The people see their corn burn up and their cattle die for lack of moisture.

RAIN MAKERS IN THE UNITED STATES.

They know the required moisture is passing right over their heads all the time—going off, may be, to rain itself down some place where they're already drowned out.

"Even the Senate Committee on Appropriations laughed at me about this. When the Appropriation bill came over from the House, I went around to my colleagues of the Senate committee and said to them, 'I want you to put $10,000 in there for rain.' They laughed at me, but they put in the $10,000 just as a personal favor. When the bill went back to the House that $10,000 amendment was knocked out. I was one of the conference committee to whom the bill was referred. I went to the other members and asked them to put in the rain appropriation just as an accommodation to me. The items in the Appropriation bill are numbered, so when the conference committee reported favorably on No. 17, nobody in the House cared to see what No. 17, a little appropriation anyhow, was, and it passed."

In accordance with this appropriation the Department of Agriculture has lately instituted the required experiments, the same being under the immediate charge of Gen. R. G. Dyrenforth, assisted by Professor Carl Myers, the balloonist, Professor Powers, author of "War and the Weather," Mr. John T. Ellis, and George E. Casler, balloonist.

The place selected for the experiments was the cattle ranch of Mr. Nelson Morris, a few miles distant from Midland, Texas, a quiet and far out of the way place, where the experimenting party were offered unlimited space and facilities for the undisturbed execution of their peculiar enterprise. Moreover, it is alleged this was a particularly dry spot, where little or no rain had fallen for three years. To this thirsty region came the rain makers, bringing with them a strange paraphernalia, consisting of several dozen balloons, kites, retorts, acids, iron filings, chlorate of potash, sulphuric acid, manganese, rackarock, dynamite, fuses, pipes, electrical wires, dynamo machines, electric exploders, etc. It was August 5 when the party reached the ranch, and from that time onward they were very busy. After much toil their explosive supplies, gas apparatus, balloons, kites, and electrical devices were got into working order, and used as follows: By means of retorts charged with chlorate of potash and manganese, oxygen gas was produced; hydrogen was generated by means of iron filings and sulphuric acid. With these gases forming a highly explosive mixture, the balloons were filled and time fuses applied.

It required four hours to charge the first balloon, and when it was ready, a dispute arose as to who should light the fuse. The chemist said the balloonist

RAIN MAKERS IN NORTHERN INDIA.

should do it, and the latter said it was the duty of the chemist. Finally the chemist touched off the fuse and the balloon sailed away and exploded at about two miles from the point of ascension. A few sticks of rackarock were exploded on the ground, and that night rain fell at Midland and Stanton, twenty-five miles away.

This was regarded as a triumphant result. After that Gen. Dyrenforth gradually increased the number of explosives until during the last week of the experiments an almost continuous cannonading was maintained.

The last of these rain-making experiments took place Aug. 26 and is thus graphically described by the correspondent of the New York *World:*

"Aug. 26.—The night was beautifully clear, and not a cloud could be seen. The heavens were dotted with stars, and from all indications it was safe to predict that no rain would fall within forty-eight hours at the least. A strong gale was blowing toward the west. Five balloons were sent up and exploded, and 200 pounds of rackarock powder and 150 pounds of dynamite set off on the ground. There was, of course, no immediate result. The barometer was rising and the needle was pointed at fair.

"By 3 o'clock in the morning a bank of clouds appeared on the western horizon at the point toward which the smoke and noise had blown. The sky rapidly became overcast, and by 4 o'clock there was rain, accompanied by thunder and lightning. When the sun rose, it was seen that the storm had come directly out of the west, and on the horizon the clouds rose in a funnel shape, like the smoke from a volcano. There was a beautiful rainbow visible at sunrise. It ceased raining at about 8 o'clock."

After hearing this news, "I think the experiments have now demonstrated the soundness of my theory," said Senator Farwell to the *World* correspondent. "For twenty years I have had no doubt rain could be produced in that way, and quite expected the experiments to be successful."

"What are your plans respecting the practical application of the invention?"

"Why, I think they could be stated in this way: The Secretary of Agriculture, you know, gets annual appropriations for the general purpose of advancing agriculture—that is, he gets money for eradicating diseases among cattle and for inspecting hogs, and for this and that similar thing. Well, when Prof. Dyrenforth makes his official report of these experiments, I expect that Mr. Rusk, the Secretary of Agriculture, will ask for $1,000,000, may be, or $500,000 any way, for rain making.

"The Department of Agriculture has its inspectors and employes in the West, and when an inspector reports that rain will be needed at a certain time in a certain region, the secretary will send on his men and appliances and make the rain. That's my idea of how it will be practically applied. Of course, I seek no control of any sort over the invention. If any State or other community wants to make rain on its own hook, there could be no objection to its doing so."

To us the most practical result likely to follow from these experiments is the extraction of money from the public treasury. We have seen how easy it was to obtain the first ten thousand dollars to aid the chimera. "I asked them to put in the rain appropriation just as an accommodation to me," says the Senator, and they did it. "Nobody in the House cared to see what No. 17, a little appropriation anyhow, was, and it passed."

The idea that rain can be precipitated by cannon firing is almost as old as gunpowder; but while there are many curious coincidences, there is no satisfactory evidence that rain was so produced. It is on a par with the Chinese mode of conquering the enemy by making a loud noise.

It is true a downpour often follows a clap of thunder; but this does not prove the rain was produced by the concussion. On the contrary, we know that rain probably results from the cooling of moisture-laden air, and simultaneously electricity may appear. Hence in thunder storms the aerial concussions are most probably the results, not the cause, of rain formation.

Nature works on a vast scale in producing rain; and it is idle to suppose that the burning of a little explosive matter can materially affect the boundless atmosphere of the skies.

In a certain sense it may be claimed that rain always follows an explosion; since all atmospheric changes are successive. If to-day is fair, fire a gun, and it will rain either to-morrow, or some following day. If to-day is rainy, fire a gun, and it will be fair either to-morrow or afterward. There appears to be just as much sense in appropriating public money for explosives to produce dryness in Alaska as to make rain, by similar means, in Texas.

In conclusion, we would warn Senator Farwell and his coadjutor rain makers that they have infringed upon a patented article, and are liable in damages. The precipitation of rain by firing aerial explosives is the invention of Mr. Daniel Ruggles, of Fredericksburg, Va., and was patented by him eleven years ago, to wit, on July 13, 1880, patent number 230,067. His patent claim is as follows:

"The mode herein described of producing rainfall, said mode consisting in conveying and exploding torpedoes or other explosive agents within the cloud realm substantially as described."

Mr. Ruggles' invention was illustrated and described in the SCIENTIFIC AMERICAN of Nov. 27, 1880. We here reproduce the engraving and description then published. "Novel Method of Precipitating Rain Falls. A patent has been recently issued to Daniel Ruggles, of Fredericksburg, Va., for a method of precipitating rainstorms, which, judging from a well known precedent, is not entirely chimerical. It has been frequently noticed that heavy cannonading is followed by a fall of rain. Profiting by this suggestion Mr. Ruggles has invented a method of producing a concussion or a series of concussions in the upper regions of the atmosphere which he believes will induce the rain."

The invention consists, in brief, of a balloon carrying torpedoes and cartridges charged with such explosives as nitroglycerine, dynamite, gun cotton, gunpowder, or fulminates, and connecting the balloon with an electrical apparatus for exploding the cartridges.

Our engraving represents an individual in the act of bringing down the rain.

Mr. Ruggles' patent is still in force, and if the invention has anything like the value which Senator Farwell places upon the obtained results, then the million dollars the senator speaks of should go to the patentee. Let justice be done to inventive genius.

For the convenience of our readers and the further elucidation of the subject, we reprint the article we published a few months ago.

[From the SCIENTIFIC AMERICAN of Dec. 20, 1890.]

"THE ARTIFICIAL PRODUCTION OF RAIN.

"The question as to whether rain can be produced by artificial means is to be tested by the United States government. On motion of Senator C. B. Farwell, of Illinois, a clause was added to the appropriation bill which provides that, under direction of the Forestry Division of the Department of Agriculture, $2,000 shall be expended in experiments having for their object the artificial production of rainfall by the explosion of dynamite.

In a communication from Senator Farwell the following theories are advanced: "My theory in regard to producing rain by explosives is based partly upon the fact that after all the great battles fought during the century heavy rainfalls have occurred. This is historical and undisputed. Senator Stanford, one of the builders of the Central Pacific Railway, informed me lately that he was compelled to do a great deal of blasting through a part of the country where rain had never been known to fall in any useful quantities and where it has never rained since, and that during the period of the blasting, which was nearly a year, it rained every day. I feel almost convinced that rain can be produced in this way. The dynamite could be exploded on the ground or up in the air, and I think I would prefer the latter. The experiment should be made in eastern Iowa, Colorado, or in western Kansas, somewhere along the railway, and my own idea would be to commence early in the morning and explode continuously for seven or eight hours."

The subject of rain production by means of concussion has been frequently discussed during the last twenty-five years. A great number of instances were stated by Francis Powers, C.E., in a volume entitled "War and the Weather, or the Artificial Production of Rain," 1871. Many cases are cited in which great battles have been followed by speedy rain. Six occurred during our war with Mexico in 1846 and 1847; nine cases of battles or skirmishes are given which occurred in 1861 in the war of the rebellion, and which were followed by rain at no great interval; forty cases are cited in 1862, thirty for 1863, twenty-eight for 1864, and six for 1865. Eighteen similar cases are also cited from among the great battles which have occurred in Europe during the past century, making a total of 137 cases. In a criticism of Mr. Powers' theory, *Silliman's Journal* said: "To this argument it may be replied that throughout the region from which his examples are mainly drawn rain falls upon an average once in three days, and probably a little more frequently; so that from the conclusion of one rain to the commencement of another, the interval is on an average but little over two days. Now battles are not usually commenced during a period of rain, generally not till some hours after the conclusion of a rain. Rain, therefore, ought to be expected in about one day after the conclusion of a battle. Now, the argument of Mr. Powers is lame in this point. He takes no precise account of the length of the interval between the conclusion of a battle and the commencement of rain, nor does he show that the interval is less than it should be if the battle had no influence in the production of the rain; and in particular he takes no account of the cases unfavorable to his theory, in which rain follows a battle only after a very long interval."

Some of the cases, however, which may be cited where the fall of rain seems to have been caused by the discharge of cannon are very striking. During the siege of Valenciennes by the allied armies in June, 1793, the weather, which had been remarkably hot and dry, became violently rainy after the cannonading commenced. Two hundred pieces of heavy artillery were employed in the attack and one hundred in the defense of the city, the whole of which were frequently in action at the same time.

At the battle of Dresden, August 27, 1813, the weather, which for some days had been serene and intensely hot, during the progress of the battle suddenly changed. Vast clouds filled the skies, and soon the surcharged moisture poured itself in a torrent of rain. At Waterloo, according to Siborne, the weather during the morning of June 17, 1815, had been oppressively hot. It was now a dead calm; not a leaf was stirring, and the atmosphere was close to an intolerable degree, while a dark, heavy, dense cloud impended over the combatants. The 18th Hussars were fully prepared and awaited the command to charge, when brigade guns on the right commenced firing for the purpose of breaking the order of the enemy's advance. The concussion seemed instantly to rebound through the still atmosphere and communicate like an electric spark with the heavily charged mass above. A violent thunder clap burst forth, which was immediately followed by a rain which has never probably been exceeded even in the tropics. In a few moments the ground became perfectly saturated.

Humboldt says that when a volcano bursts out in South America during a dry season, it sometimes changes it into a rainy one. It is well known that in very hot calm weather the burning of woods, long grass, and other combustible materials produces rain. Very extensive fires in Nova Scotia are so generally followed by heavy floods of rain that there is ground for believing that the enormous pillars of smoke have some share in producing them.

Captain James Allen, acting signal officer of the War Department, in reply to interrogatories recently addressed to him regarding the probability of producing rain by artificial means, said: "One fact would seem to be easily admitted, that an attempt to explode gunpowder in order to practically demonstrate the advisability of attempts in rain production should at first be made after most careful consideration of the atmospheric conditions. For example, if these explosions should be made in the center of a high area, as shown by our weather maps, or even after a low area has passed any point, we may be absolutely certain no rain will follow. The first experiments should be undertaken to the southeast or east of a low area, and 300 to 600 miles from the center.

"Observing stations should be established every 5 or 10 miles for 200 miles to the eastward of the point of explosion. If the explosions are made in a comparatively clear sky, and after that unmistakable clouds are observed to the eastward and not to the westward, some connection may be surmised. It must be said, however, that even if the production of rain be practicable, it can only be for a very limited area, and it is believed that any benefit which can possibly arise from such rain can never amount to the expense of the enterprise."

The opinion of Captain Allen is similar to that of President H. C. Russell, of the Royal Society of New South Wales, contained in an anniversary address delivered in 1884. He says: "It would seem unreasonable to look for the economical production of rain under ordinary circumstances, and our only chance would be to take advantage of a time when the atmosphere is in the condition called unstable equilibrium, or when a cold current overlies a warm one. If under these conditions we could set the warm current moving upward, and once flowing into the cold one, a considerable quantity of rain might fall, but this favorable condition seldom exists in nature."

The experiment of producing rain by exploding dynamite is about to be tried, and the result will be awaited with much interest."

The foregoing was published in the SCIENTIFIC AMERICAN of September 5th.

After the rain makers had telegraphed from Texas to all parts of the country announcing the wonderful success of their bombs, it was discovered that the meteorological records for that locality had indicated probabilities for rain for a day or two in advance of the firing, and that the rain would have fallen all the same without any burning of powder or sending up of balloons. There seems to be little room for doubt that the swinging of a Hindoo head downward, as illustrated in our engraving, is just as effective for producing rain as the making of loud noises.

The strongest theory and argument of the American rain makers, to wit, that rain is often occasioned by claps of thunder, will not bear the test of scientific research. Electrical action may take place when rain is formed and the thunder may be therefore a result of rain formation, not the cause. A correspondent in *Nature* takes the same view. Among other comments upon the Texas experiments, he says:

"It is needless to say that popular theorizing, on this as on most other physical phenomena, concerns itself chiefly with the things that are most obvious to the senses, but often have little or nothing to do with the process. Thus we find that attention has been fixed on the explosion; and we are told that the idea of breaking clouds by producing a motion in the air, and so destroying the equilibrium of the suspended globules of moisture, which in coalescence form rain, is not a new one; that it was the custom to keep a cannon in French villages, with which to fire at passing clouds and thus hasten the downpour; that at the battles of Dresden and Waterloo the concussion of the air by the cannonade led to the descent of torrential showers; and we are reminded that 'in the same way' rain follows a peal of thunder caused by the passage of a lightning flash through a moisture-laden atmosphere, etc. Now all this noise and disturbance have no more to do with the production of rainfall than has the thrashing which the village rain-maker of Central India receives from his fellow villagers to stimulate him to fresh exertions when he is thought to have neglected the performance of his official duties, or the London street-boy's whistle, with which Sir Samuel Baker startled a rain-making king in the Southern Soudan, and which was followed by such a deluge that even the rain-making potentate implored him to arrest the working of the spell.* The effect of a concussion, as such, is to produce an instantaneous compression of the air, and a momentary heating in a wave which travels away at the rate of about 1,000 feet per second, and is incapable of generating any translational movement of the atmosphere, and certainly of promoting condensation. Nor do we know of any recorded observations in support of the idea that it can cause the coalescence of cloud corpuscles into raindrops. Neither does the concussion of the air by a thunder clap stand to the downpour that follows it in the physical relation of cause to effect. In this case Sir John Herschel adopts the opinion originally put forward by Eeles, that the order of succession is the reverse of that here assumed, that the formation of the rain-drop is the antecedent phenomenon, and the lightning flash (and *ergo* the thunder) the consequent; the electrical discharge being determined by the sudden concentration of the electricity of (say) one thousand corpuscles on the surface of the single resulting rain-drop, in which case its intensity would be increased ten-fold. What causes the coalescence is still a matter of much obscurity, though some light has been thrown upon it by the ingenious experiment exhibited by Mr. Shelford Bidwell at the Royal Society's *conversazione* on May 14, 1890, and described in vol. xlii. (p. 91) of this journal. When the shadow of a small (condensing) steam jet was thrown upon a white screen, under ordinary conditions, it was of feeble intensity and of a neutral tint; but when the jet was electrified, the density of the shadow was at once greatly increased, and it assumed a peculiar orange-brown tint. It appeared that electrification promoted the coalescence of the exceedingly minute particles of water contained in the jet, thus forming drops large enough to obstruct the more refrangible rays of light. On this view, then, electrification would appear to be the cause of coalescence, and the electrical discharge the ulterior result; but as yet we know too little of the molecular processes concerned in the formation of a rain-drop to attempt anything like a complete theory.

"In conclusion, while we cannot but recognize the high interest of General Dyrenforth's results, with the imperfect information at present before us we cannot regard them as conclusive. It is the characteristic weakness of all experiments of the kind that many of

* This story has probably been told by Sir Samuel in one of his well-known works on Africa, and is too good to be spoilt by condensation. It is, at all events, authentic, the present writer having heard it from his own lips at a Simla dinner-table.

the essential circumstances are scarcely ever recorded, or perhaps even capable of being brought within the limits of observation; and thus the logical conditions of a proved conclusion cannot be fulfilled. For instance, it is very unlikely that anything is known of the state of the atmosphere in respect of its humidity and its vertical temperature decrement at the elevation at which the balloons were exploded, and yet, as we have seen, these data lie at the very root of the whole matter. However, arrangements are being made for further operations at El Paso and in western Kansas, so that it will not be long before the highly interesting and practically important problem of stimulating the precipitation of rain will receive a more satisfactory solution. H. F. B."

ARTIFICIAL RAIN MAKING.*

By Prof. EDWIN J. HOUSTON.

WHENEVER a large mass of air is cooled below the temperature of its dew point, the moisture it can no longer hold as invisible vapor becomes visible. If the reduction of temperature be but slight, the vapor appears as fog, mist, or cloud; if the reduction be considerable, as rain or snow.

There has been no little attention given lately to the question as to whether or not rain can be caused to fall at pleasure on any given section of the earth—rain machines, or artificial rain producers, consisting essentially of devices whereby explosions of nitro-glycerine, or other similar substances, are obtained at fairly considerable elevations in mid-air, have been tried in different forms. As to the success of these attempts at the artificial production of rain, the testimony appears to be uncertain or contradictory.

The idea of rain making by mid-air explosions is probably based on the rains that are generally believed to attend or follow great battles, 4th of July celebrations of the Chinese character, and volcanic eruptions. Passing by the evidences produced by either the warlike or the peaceful burning of gunpowder, which at best are but vague, it may be remarked that volcanic eruptions may produce very heavy rainfalls, not only because the force of the eruption and the intense heat cause upward currents in the air, but also because of the vast quantities of vapor of water that escape from most volcanoes during their eruptions.

There is a fascination in witnessing man's struggle with the forces of nature; a struggle, be it understood, not made to oppose such forces, but rather to direct them. The former effort would be foolish, the latter must meet with success if properly directed.

Do the scientific facts, as far as known to meteorology, give any encouragement for the continuance of the efforts of the would-be rain makers? Let us inquire:

It is now generally agreed that the lowering of temperature necessary for the production of rain may be obtained in the following ways:

(1.) By the intermingling of masses of warm and cold air.

(2.) By the carrying of warm, moist air into a cold place.

In any case the cause of the rain is, briefly, the cooling of the air until it is unable to retain all the moisture it formerly held as invisible vapor, and deposits the excess in a visible form as rain.

The quantity of the rainfall will, therefore, depend both on the amount of moisture present in the air and on the extent of reduction of temperature produced.

The first method, viz., the lowering of temperature by the intermingling of masses of warm and cold air, can never produce any very considerable rainfall, since, though the warm air is cooled by its mixture with cold air, and the tendency is, therefore, to cause the mixed air to become relatively moister, yet at the same time the cold air is made warmer, and, therefore, relatively drier. Drizzling rains might be produced in this manner, but scarcely ever heavy rainfalls, unless both the cold and the warm air contain large quantities of moisture.

There remains, therefore, but the second way of lowering the temperature of the air, viz., by the carrying of the warm air into a colder place. This can be accomplished in three different ways:

(1.) By a change of latitude, or by a warm, moist air blowing into a colder latitude. In general, the equatorial currents blowing toward the poles are the chief rain producers.

(2.) By a change in altitude, effected by an ascending current, due to a heated area. Here the lowering of the temperature is due not only to the cold of elevation, but also to that produced by the expansion of the air under lower pressure.

(3.) By a change in altitude, due to a mountain range opposing the progress of a wind, and thereby necessitating its gradually creeping up the sides of the mountain.

In any of these ways heavy rains may be produced, and, in point of fact, they are probably the only ways in which heavy rains are generally produced.

Applying the preceding principles to the case of the modern rain machine, let us inquire as to the probabilities of its successful operation. The simultaneous or the successive explosion of large quantities of any high explosive in the upper regions of the atmosphere must produce, in general, a rapid and more or less thorough mixing or stirring of the surrounding air.

The sudden expansion of the air both by the heat liberated by the explosion and by the gases evolved during the explosion is attended by a rush outward, followed by a rush of air inward, toward the explosion center. The direction of this latter rush is generally radially inward. In addition to these inward motions, the heat generated may tend to produce a slight upward motion; the general effect must be, however, to produce a mixing or churning rather than an upward motion.

The immediate effect of the explosion is to produce a miniature area of low barometer, caused by the radial rush of air toward the explosion center, and by whatever ascending current that may result from the liberation of heat.

It would be reasonable to suppose that if the explosion produces any direct effect in atmospheric conditions, the area of low barometer should follow immediately, or nearly so, after the explosion. Have such changes in the barometric pressure been noticed to follow such mid-air explosion?

So far as the mixing motion is concerned, its action to produce a fall of rain must be slight. The ascending motion might cause a rainfall, but as this motion is slight in extent, its action under ordinary conditions must at best be but insignificant.

In either case, any decrease in temperature, and consequent increase in relative humidity, must necessarily be slightly decreased by the dry and heated gases evolved during the explosion of such substances as nitro-glycerine, dynamite, or gunpowder.

It might be supposed from the above considerations that balloons containing an explosive mixture of hydrogen and oxygen would be preferable to those carrying nitro-glycerine dynamite or gunpowder, since in the former case the vapor of water results from the explosion, and in the latter dry gases. It must be remembered, however, that the explosion of mixed oxygen and hydrogen produces for the greater part a collapse or radial rush inward toward the explosion center, while the explosion of gunpowder or nitro-glycerine produces for the greater part a radial rush from such center.

A circumstance that appears to have been lost sight of in all the recent attempts at rain making is that such attempts have been apparently made irregardless of the hygrometric conditions of the air. As rain is but the excess of moisture, the warm moist air is unable, when sufficiently cooled, to retain the amount of the fall, which will depend, as stated, on the quantity of moisture in the air as well as on the extent of the chilling action following the explosion or other cause. To attempt to produce rain by explosions in mid-air, irrespective of the quantity of moisture in the air, is to attempt to cause water to fall from the air when practically none is present. This is not only illogical, but absurd.

It may be thought by some that the concussions caused by mid-air explosions might result in such a general movement of the surrounding air as to cause rain to fall over an extended area. The flash of the explosion is followed by a sudden movement of the air, causing the noise of the explosion. The phenomena of lightning and thunder are somewhat similar to those of artificial mid-air explosions. First we have the lightning flash, and subsequently the thunder, which is a violent concussion of air. Does this concussion bring down a heavier rainfall? Popularly it is believed to do so, but the general opinion of the scientific world is that the lightning flash is the effect of a rapid condensation of the aqueous vapor, *i. e.*, of a heavier rainfall, and not the cause of such a fall. That is to say, the high potency of the lightning flash is due to the enormous decrease in the surfaces of the already charged rain drops over that of the surfaces of the thousands of the separate drops that coalesce to form the single drops.

Nevertheless, the liberation of heat energy and the rapid admixture of air following the disruptive discharge may slightly increase the rainfall, or may act as a determining cause of rain over an extended area.

There is this difference between the lightning flash and the flash of an explosion, viz.: The former occurs over a comparatively great length of path, *i.e.*, a space of small breadth and depth but great length.

The latter occurs in a comparatively limited space, the three dimensions of which are nearly equal.

Though lightning is not a cause of rain, there can be no doubt that if rain can be artificially produced during a period in which there is much free electricity in the air, the storm will be attended by lightning and thunder. If then there be any increase of rain due to the presence of lightning, artificial rain making will be more liable to succeed when the potential of the air, as regards the earth or neighboring clouds, is comparatively high.

The enormous expenditure of energy required to produce a rain storm over an extended area is a circumstance that would appear to give but little encouragement to man's many efforts in this direction. The amount of energy liberated by the greatest explosion man has yet effected in mid-air is but insignificant when compared to the energy liberated by nature during even a comparatively limited fall of rain.

There is, however, an important consideration bearing on the question of the probable success of rain making by mid-air explosions that gives to such attempts a far greater probability of success than would appear to be warranted from the facts already enumerated. Presupposing the existence of a sufficient mass of moist air, at preferably a comparatively high difference of potential as compared with the neighboring air or the earth, a mid-air explosion might act as the determining cause of rainfall over a wide area. The balance of the energy requisite therefor being supplied by the moist air. In a mass of very moist air there exists a store of energy which, if liberated, would suffice to cause movements of the air of vast extent. When the vapor of the air is condensed, the potential energy becomes kinetic, and, being liberated by the heat, causes ascending currents, which produce a further condensation of moisture, and further liberation of energy previously locked up in the vapor.

There sometimes exist conditions in the air in which it is, so to speak, in a state of very unstable equilibrium, and a slight determining cause may result in the liberation of the stored-up energy with a resulting heavy rainfall. In such cases it would appear that there are no reasons why an explosion in mid-air should not be followed by rain. At the same time it is not unreasonable to suppose that the natural causes would, in many cases, continue to act and thus cause rain without artificial aid.

There are, however, meteorological conditions that probably frequently exist in certain latitudes in which heavy rains might be artificially produced by mid-air disturbances when without such disturbances no rainfall would occur. Should, for example, a layer of warm, moist air exist between the earth's surface and a higher layer of cold, moist air, separated by a comparatively thin layer of air, and such conditions exist as to maintain the two layers separate, then the breaking or piercing of the intermediate separating layer might permit such an up-rush of the warmer air through the opening that the liberation of its stored-up energy through the condensation of its moisture would result in a general up-rush of the warm moist air and the consequent production of an extended area of low barometer. In other words, the artificial rupture of the separating layer would result in the formation of a true storm center and a heavy rainfall of considerable dimensions. In such cases it would appear:

1. That mid-air explosions will be more effective than explosions on the earth's surface.

2. That direct mid-air explosions *i. e.*, explosions in which the general effect of the liberated energy is to produce an upward rush of air, would be more effective than undirected, haphazard explosions.

If in such cases considerable difference of potential exist between the layers of air, or between that of the air generally and the earth, the lightning flashes would unquestionably be effective in piercing the separating layer, especially if, as would probably be the case, the general direction of the discharge be between the layers of cold and warm air.

Since, as we have seen, it is the ascending current that causes the heaviest rainfall, it would appear that mid-air explosions of such a character as to produce in general an upward rush of air would be probably more successful than undirected, haphazard explosions in mid-air. Such movements might advantageously be effected by the liberation of rockets with enlarged conical heads, or any form of fire work that would move generally upward.

Since success in artificial rain making is probably dependent on the meteorological conditions, both of the lower and upper layers of the atmosphere, efforts should be made to enlarge our present very limited knowledge of such conditions.

Captive balloons, containing registering electrometers, tele-thermometers, tele-hygrometers, tele-anemometers, etc., might be connected by wires with recording apparatus placed on the earth's surface. The cost of maintaining such aerial stations of observation would be but insignificant when compared with the benefit that would accrue not only toward the solution of the problem as to the probable success in rain making, but the general operations of the United States Weather Bureau in particular, or of meteorology in general.

During the general prevalence of moist warm air, when but a slight cooling is necessary to cause a general downpour, effective rain making might be obtained by the sudden breaking or opening of cylinders of liquefied gases, whose expansion would cause an intense chilling of the surrounding air; such cylinders could be readily opened by means of earth-controlled electromagnets.

The following general conclusions may, in view of the present state of metallurgical science, be properly drawn concerning the artificial production of rain:

(1.) That rain can never be made to fall at will by mid-air explosions on any part of the earth's surface, irrespective of the climatic conditions there existing.

(2.) That during certain meteorological conditions, mid-air explosions may result in rainfall over extended areas.

(3.) That the liberation of energy necessary for such rainfalls is not due, except initially, to the mid-air explosions, but to the energy stored up in the moist air from which the rain is derived.

(4.) That the meteorological conditions which must exist for the successful action of mid-air explosions would probably, in most though not in all cases, themselves result in a natural production of rain.

(5.) That a comparatively high difference of electric potential between different parts of the air or between the air and the earth is possibly favorable when taken in connection with other meteorological conditions for artificial rain making.

(6.) That an undirected mid-air explosion is not as likely to produce rain as an explosion in which the main tendency of the energy liberated is to cause a general up-rush of the air.

* Read before the electrical section of the Franklin Institute, Sept. 8, 1891.

THE CLOUD COMPELLERS AND THE PRESS.

SINCE the *North American Review* published Professor Newcomb's simple but conclusive demonstration of the complete impossibility of creating or evoking rain by such means as General Dyrenforth has been employing, the newspapers, which originally treated the subject very cautiously, or evidently shared the popular tendency to believe that there "might be something in it," especially because if there *was* something in it, it would confound the experts (a thing most dear to the lay imagination), have taken heart, and are now pretty generally making the whole business a subject for polished ridicule, delivered with that knowing air which is one of the accomplishments of journalism. Some one of them (the *Evening Post*, for instance, which has the knowingest air of all, and which published some months ago, without venturing any critical comment, a long interview with General Dyrenforth, in which the concussion theory was alluringly set forth) might have gained some credit by boldly denouncing the humbug at the outset. There is little to be gained now.

So far as I have seen, not one of the daily newspapers has recalled that the appropriation made by Congress for rain making was first ordered to be expended by Mr. B. E. Fernow, chief of the Forestry Division of the Department of Agriculture; that Mr. Fernow declined to expend it, and, in his annual report, gave conclusive reasons for regarding the proposed experiments as a waste of public money; that the appropriation was thereupon increased, and put into the hands of the ex-Commissioner of Patents; and, finally, that there is a United States patent covering the process, which General Dyrenforth has been advertising at the public expense. Even if our newspapers cannot detect a scientific fallacy, they ought to be able to recognize a "job."—*R. W. R. in Eng. and Min. Jour.*

THE WEATHER DEBATING SOCIETY.

THERE are now so many cloud-compelling rain producers turning up that any opulent person who is interested in the weather can hire one of them for his own convenience. But suppose a man who would like to enjoy a shower on a warm afternoon orders his cloud compeller to produce one at a time when his next door neighbor desires to take a walk in his garden under the sunshine, what will ensue? Will the

rain producer be liable to be sued for damages by his neighbor, or will the case be settled by arbitration?

These questions are fit to be taken up by the Weather Debating Society, now that so many rain producers are offering their services at a low price.—*N. Y. Sun.*

THE SYSTEM OF MILITARY DOVE COTES IN EUROPE.*

Spain.—Spain is one of the countries in which the rearing of carrier pigeons and the organization of military dove cotes has taken the most rapid development.

The long domination of the Arabian Caliphs in the south of the peninsula, who in their native country had organized in a remarkable manner all their postal services by means of pigeons, the domination of the Spaniards themselves in Flanders, where the aerial messengers had played a great role in sieges, and the spirit of initiative and the love of study carried to a high degree in the corps of military engineers in this country, all contributed to this happy result.

The first regular experiments, however, date no further back than to 1879, the epoch at which an experimental station was established at the military school of Guadalajara by General Reina with birds of Belgian origin. These experiments having been successful, the military dove cotes multiplied, and a royal decree of August, 14, 1889, fixed the number of them at eighteen, thus distributed; four on the French frontier, at Figueras, Jaca, Pamplona and the intrenched camp of Oyarsun; one on the maritime frontier of the northwest of the peninsula in the important fortress of Ferrol; two upon the Portuguese frontier at Ciudad Rodrigo and Badajoz; one upon the English frontier at Tarifa; two upon the frontier of the Moors in Africa, at Ceuta and Melilla; and two in the Balearic Islands, Palma and Mahon.

The central dove cote is at Madrid, and communicates with the preceding, either directly through ten of them, or by the aid of five intermediate stations, viz.: Valladolid for the place of Ferrol, Zaragoza for that of Figueras, Valencia for those of Palma and Mahon, Cordova for Ceuta and Tarifa, and Malaga for Melilla.

The greatest distance between two stations designed to communicate directly is that from Madrid to Malaga amounting to 240 miles. The shortest upon *terra firma* is 90 miles, between Madrid and Valladolid. As regards trips by sea, the longest is from Valencia to Mahon (238 miles), and the shortest from Tarifa to Ceuta (16 miles).

Spain as figured in the map (Fig. 2), borrowed from the *Memorial de Ingenieros del Ejercito*, gives, moreover, a very clear idea of the system of that country.

Spain up to the present has derived all of its birds from Belgium, but is tending to produce a special breed, more resistent to inclement weather, and especially to dryness, by crossing with an excellent indigenous breed.

Certain Spanish pigeon fanciers, having remarked that many pigeons have a repugnance to lifting the wickets, and thus lose time before deciding to re-enter the cote, have adopted the ingenious arrangement shown in Fig. 1.

This arrangement is based upon the observation that the pigeon can pass through an opening four inches wide when it has the facility of reaching it without being obliged to fly, but that it cannot pass through an aperture of the same width when it is necessary to reach it by flying, that is to say, with wings outspread. It will be seen, then, that it will suffice to separate the compartment, A, from compartment, B, in the interior of the cote, in order that the pigeons entering B may not be able to get out again, and those making their exit from A may not be able to re-enter. It is probable that good results will be reached because of the care that is taken in the cotes of this country to preserve a complete filiation for each pigeon. There is inscribed upon its wings not only its number of registration, but also the numbers of its parents, and its sex. In this way it is easy to ascertain which of the birds gives the best products, and thus to permit of a selection of producers.

Portugal.—Portugal preceded Spain in the establishment of military dove cotes, although its very warm climate was not very favorable to the rearing of the first breeds of carrier pigeons introduced from Belgium. The first experiments date back to 1876. A few years afterward there were five stations in regular service: Lisbon, with 400 pigeons; Elvas, with 300; Vedra Novas, with 250; Taneos, with 150; and Setabal with 100. The three latter have since been suppressed and been replaced by twelve others, so that the present system, such as it was constituted by a statute of September 7th, 1888, consists of fourteen stations, which are very near each other, on account of the mountains that cover the country and the birds of prey by which they are inhabited. These stations are Lisbon (the central station in direct communication with almost all of the others), Porto, Valencia, Chaves, Braganza, Almeida, Guarda, Coimbra, Castillo, Branco, Abrantes, Elvas, Peniche, Beja and Lagos.

Russia.—Almost immediately after the war of 1870, the Russian staff office began to direct its attention to carrier pigeons, and an experimental station was established at Warsaw. A ministerial decree of the 21st of October, 1887, fixed the basis of the service, which is placed under the direction of the army engineer corps.

The establishments are divided into four categories according to the number of directions with which they are in relation. The *personnel* of the establishments of the first class (corresponding in four directions) consists of a director (lieutenant colonel), four pigeon superintendents, and eight orderlies; for the establishments of the second class (corresponding in three directions), there is a director, three superintendents, and six orderlies; for the establishments of the third class (two directions for correspondence) there is a director, two superintendents and four orderlies; and for those of the fourth class (correspondence in but one direction), there is a director, one superintendent and two orderlies.

There exist at present in Russia five stations or establishments, viz.: (1) Brest-Litowsk, central station, and establishment of the first class, corresponding in four directions: Novo-Georgiewsk (129 miles), Warsaw (108 miles), Ivangorod (83 miles), and Luninetz (126 miles). This station has 1,000 pigeons. (2) Warsaw, an establishment of the second class connected with Novo-Georgiewsk (16 miles), with Brest (108 miles) and with Ivangorod (54 miles). It has a stock of 750 pigeons. (3) Ivangorod, an establishment of the third class, connected with Warsaw (54 miles) and Brest-Litowsk (83 miles). It has 500 pigeons. (4) Novo-Georgiewsk, an establishment also of the third class, connected with Brest (126 miles) and Warsaw (16 miles). (5) Luninetz, an establishment of the fourth class, corresponding solely with Brest, and possessing 250 pigeons. It is probable that other stations are in process of formation upon the eastern frontier, with Kiew for a center.

Switzerland.—In 1878, Colonel de Loes, of Aigle, received from France fifty pairs of carrier pigeons, which were delivered to the Federal Council; but they were distributed at hazard among the various cantons, and no advantage was derived therefrom.

The following year, however, some experiments were made in order to ascertain whether carrier pigeons could fly to great heights, and whether they were capable of finding their way again on starting from snow-clad summits as well as from stations of less altitude. The decree organizing the service of military pigeons was promulgated on the 24th of January, 1889. It contained the following provisions:

"Art. I. A subsidy for breeding is offered to persons owning a certain number of carrier pigeons.

"Art. II. The training of these pigeons must be done in Switzerland. This is an important point to be observed.

"Art. III. The societies that lay claim to the subsidy must, as regards rearing, submit to the instructions of the staff office, which will furnish them with all the data in this regard, and, particularly, fix the site of the dove cotes.

"Art. IV. Every year, aside from the ordinary races, there will be a contest, in which the journey will vary from ninety to one hundred and twenty miles.

"Art. V. From the beginning, the societies will have to make known to the staff office: (1) the number of their pigeons capable of being utilized for correspondence, and (2) the number of the members that make up the association.

"Art. VI. For each race there will be drawn up a very exact official report, in which is given the starting and arrival of each pigeon, the temperature of the air, and the direction of the wind. This document will be sent to the staff office in order that there may be easily ascertained from it the damages resulting from each start and especially the losses of pigeons.

"Art VII. The societies that execute at least six times per year the services prescribed by the staff office will receive the following allowances: (1) The societies that rear at least 100 pigeons capable of doing service will receive a sum that may reach as high as $14; (2) those that rear at least 200, will receive as high as $24; and (3) above 300, as high as $32."

The central dove cote is at Thun, and corresponds with three stations, Bale, Zurich, and Weesen, all three upon the frontiers of Germany or Austria.

Austria.—The first society of pigeon fanciers was founded in Austria during the year 1873, and it was not until 1875 that the first military pigeon cote was established, and that at Comorn. In 1882, a second was organized at Cracow. Since then, four others have been projected in the central points of the mountainous regions of the frontier, at Franzenfeste, for the Tyrol, at Karlsburg, for Transylvania, at Serajewo, for Bosnia, and at Mostar for Herzegovina. But none of these stations appears as yet to have been created, very probably for want of money, for it will be necessary to have intermediate stations in connection with them. The government is endeavoring to supply the deficiency by encouraging private societies with all its power, and gratuitously granting the wood necessary for the erection of a cote to the officers and state employes who are engaged in breeding and training pigeons with a view to the carrying of dispatches. Moreover, the railways are allowing notable reductions of fare to those who accompany the pigeons in

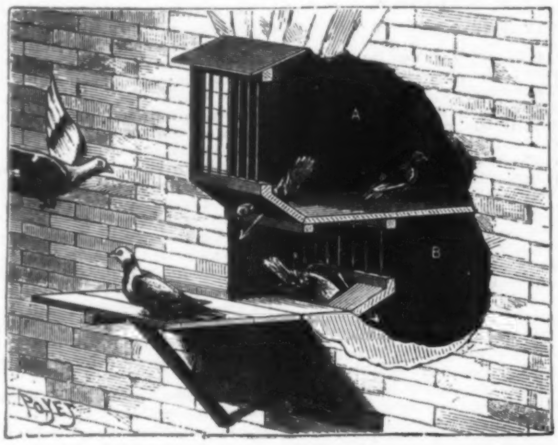


FIG. 1.—SPANISH MILITARY PIGEON HOUSE.

FIG. 2.—MAP OF THE SYSTEMS OF MILITARY DOVE COTES IN EUROPE.

France—1. Mont Valerien. 2. Paris. 3. Vincennes. 4. Lille. 5. Douai. 6. Valenciennes. 7. Maubeuge. 8. Mezieres. 9. Verdun. 10. Toul. 11. Langres. 12. Belfort. 13. Besancon. 14. Lyons. 15. Marseilles. 16. Perpignan. 17. Grenoble. 18. Briancon. *Portugal*—1. Lisbon. 2. Oporto. 3. Valencia. 4. Chaves. 5. Braganza. 6. Almeida. 7. Guarda. 8. Coimbra. 9. Castello Branco. 10. Abrantes. 11. Elvas. 12. Peniche. 13. Beja. 14. Lagos. *Spain*—1. Madrid. 2. Figueras. 3. Iaca. 4. Pamplona. 5. Oyarsun. 6. Ferrol. 7. Ciudad-Rodrigo. 8. Badajoz. 9. Tarifa. 10. Ceuta. 11. Melilla. 12. Palma. 13. Mahon. 14. Zaragoza. 15. Valladolid. 16. Cordova. 17. Malaga. 18. Valencia. *Italy*—1. Rome. 2. Ancona. 3. Bologna. 4. Verona. 5. Placenza. 6. Alexandria. 7. Mont Cenis. 8. Fenestrella. 9. Exilles. 10. Vinadlo. 11. La Maddalena. 12. Cagliari. 13. Gaeta. 14. Genoa. *Switzerland*—1. Thun. 2. Bale. 3. Zurich. 4. Weesen. *Germany*—1. Berlin. 2. Cologne. 3. Metz. 4. Mayence. 5. Wurtzburg. 6. Strasburg. 7. Schwetzingen. 8. Wilhelmshaven. 9. Tonning. 10. Kiel. 11. Stettin. 12. Dantzig. 13. Koenigsberg. 14. Thorn. 15. Posen. 16. Breslau. 17. Torgau. *Austria*—1. Comorn. 2. Cracow. 3. Franzenfest. 4. Karlsburg. 5. Serajewo. 6. Mostar. 7. Trieste. *Denmark*—Copenhagen. *Sweden*—Carlsburg. *Russia*—1. Brest-Litowsk. 2. Warsaw. 3. Novo-Georgiewsk. 4. Ivangorod. 5. Luninetz.

* Continued from SUPPLEMENT, No. 819, p. 13089.

their voyages, and the military stations are delivering a very good breed of pigeons to amateurs at a minimum price of 25 cts.

Sweden.—Sweden as yet appears to have but one station, and that was established in 1886 in the fortress of Carlsburg.

Denmark.—Knowing the great services that the carrier pigeons of Paris rendered in 1870-71, some citizens clubbed together in order to train pigeons in view of serving as aerial messengers during time of war.

The society is entirely civil, but the members have promised that in time of war they will put all their pigeons at the disposal of the minister of war. The minister annually rewards those members whose pigeons have proved the swiftest. Her Majesty the Queen is the protector of the society, and his Highness Prince Waldemar is the honorary president of it. The society consists of twelve sections, one at Copenhagen and the others in the provincial cities. The president is Lieutenant-colonel Holboll, who closely watches the pigeon fancying movement in the west of Europe, and yearly organizes competitions.

Belgium.—The large number of private individuals owning carrier pigeons in Belgium, where every commune has at least one society of pigeon fanciers, renders useless in this country the organization of military dove cotes. Lieutenant Gigot has nevertheless studied the arrangement that it would be proper to adopt were it desired to have a perfectly trained *personnel* in time of war. It would suffice at Anvers, Liege and Namur to establish stations that would all correspond with each other. In order to secure a six months' service, it would require a total of five or six thousand pigeons. The number of those at present existing in Belgium is estimated to be more than 600,000.

Holland.—Peaceable Holland has not, any more than has Belgium, thought it its duty to organize military dove cotes upon its territory, where civil societies abound; but regular postal services by the aid of pigeons have been established by its colonial army in the islands of Java and Sumatra.

England.—England has established cotes in some of its garrisoned cities, and employs pigeons for the surveillance of its coasts, but we have found no precise details upon this subject. In 1886, the Duke of Cambridge had a few interesting experiments made upon aerial correspondence during the grand maneuvers.—*Lt. Col. De Rochas, in La Nature.*

ROPE BRIDGES AND THEIR MILITARY APPLICATIONS.

MUCH attention has been paid for some years past to the subject of the quick repairing of railway bridges

FIG. 1.—PUTTING A GISCLARD BRIDGE IN PLACE.

in time of war by means of a material all prepared in advance. The experience of the last campaigns, from the war of the rebellion to the Turko-Russian war, has proved, in fact, that local resources are in most cases inadequate to permit of effecting such repairs quickly enough, even though one has at his disposal, as in America, inexhaustible forests from which may be obtained at will the wherewithal to construct the huge scaffoldings or trestles that form the simplest while at the same time the most rudimentary means of crossing a gap.

We have many times described the various systems of metallic bridges proposed by our engineers to satisfy every military engineer. Some, such as Col. Marcille's bridge, consist of wholly mounted and relatively heavy sections, that are carried by rail and assembled end to end. Others form reticulated systems capable of being taken apart up to the extreme limits at which the pieces can be carried by men, thus permitting of their being moved to any point whatever, even though no railway reaches it. This is a great advantage for the simultaneous reconstruction of several bridges situated upon the same line. The bridges of this nature are numerous. It will suffice to mention those of Mr. Eiffel and Lt. Col. Henry. Both have been the object of numerous experiments that have shown all the resources that they offer to the engineer, not only in case of war, but also in time of peace, when it is a question of promptly remedying an accident, as at Artemare, or of forming a provisional passage without travel being impeded, as at Argenteuil, and also recently on the Ourcq canal.

These various systems respond to a well defined and limited need, but it is not useless to ask whether, aside from railway bridges, it will not be possible, by the same process, to assure of the re-establishment of bridges situated upon ordinary roadways. Although there is no doubt, in fact, that the technical problem may be easily solved by means of metallic bridges and light foot bridges easily put in place, it is not less evident that, in time of peace, there might be constructed and preserved the large quantity of equipments that would be necessary, so that, at the proper time, one might be almost sure of having some of them wherever the need thereof might be felt. Without speaking of the impediment that they would prove to armies that had to carry them in their train, it is certain that this accumulation of *materiel* would be out of proportion to the object in view. To cite an example of the multiplicity of needs which it is necessary to fulfill, it will suffice to remark that in certain broken regions it is not rare to find, on a stretch of a few miles, five or six large bridges, the breakage of which would constitute a great obstacle, and which it would be absolutely necessary to repair in order that the army might pursue its way. No material interest would be able to suffice for the reconstruction of so numerous bridges and satisfy like exigences so often repeated. As in the past, we shall therefore have to rely again, in great part at least, upon local resources, put to profit by the engineer corps.

We have only to look at the diversity of the processes brought into requisition in past wars by the military engineers, in order to get an idea of the complexity of the problem. There is no general method applicable to all cases, and every one endeavors to adopt the equally varied materials and resources that he has at hand to the varied circumstances that present themselves.

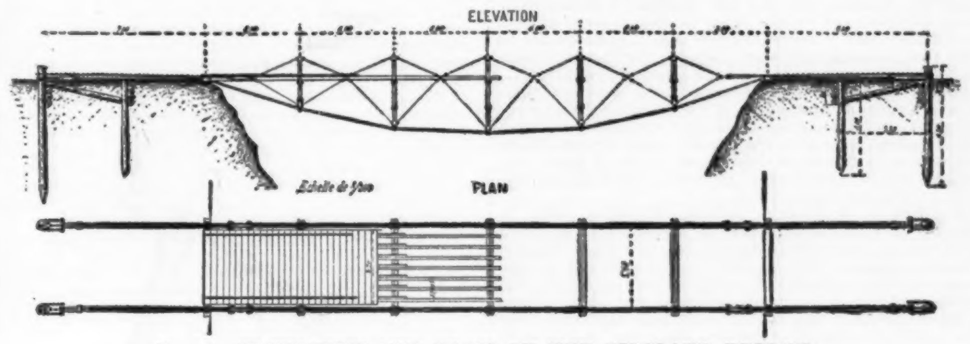


FIG. 2.—ELEVATION AND PLAN OF THE GISCLARD BRIDGE.

However, it would not be impossible to classify this multitude of more or less brilliant solutions and to prepare at least for the utilization of these chance materials by carrying along the light pieces whose manufacture requires a length of time out of proportion to what one has at his disposal. It was thus that the Americans operated under many circumstances during the war of the rebellion. The system of lattice girders that they often adopted was very effective. The wood was easily found *in situ*, and it therefore sufficed to carry along the pieces of iron that were to serve for the uniting of the various frameworks.

In Europe it will not often be possible to depend upon wood of large section. Thus, the passage of the Danube in 1877 presented very serious difficulties, due to the want of raft wood, of which the markets had been drained in advance. In default of forests or well stocked yards, the demolition of the neighboring houses (which would not be a very economical means, nor a very humane one in time of peace) will always permit of finding the materials that are the most indispensable for the construction of a foot bridge. It will be the duty of military engineers to determine the best conditions for the use of them, in order that the crossing of a chasm may be effected as rapidly as possible, and it will be then that it will be important to make a judicious selection from among all the processes known and practiced.

Among such processes, it seems that, up to the present, sufficient attention has not been paid to funicular arrangements, which lend themselves so well to a rapid construction with light materials.

Apart from the timber, which may be found everywhere, it suffices to carry some ropes, assembling irons, and pulley blocks, all of which are objects that do not weigh much and do not cause an exaggerated encumberment. As for the work itself, that can be done without calling in the aid of a large number of special laborers.

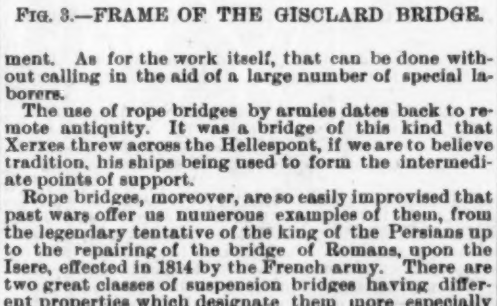


FIG. 3.—FRAME OF THE GISCLARD BRIDGE.

The use of rope bridges by armies dates back to remote antiquity. It was a bridge of this kind that Xerxes threw across the Hellespont, if we are to believe tradition, his ships being used to form the intermediate points of support.

Rope bridges, moreover, are so easily improvised that past wars offer us numerous examples of them, from the legendary tentative of the king of the Persians up to the repairing of the bridge of Romans, upon the Isere, effected in 1814 by the French army. There are two great classes of suspension bridges having different properties which designate them more especially in different cases.

SUSPENSION BRIDGES WITH PARABOLIC CABLES.

These lend themselves well to permanent constructions and permit of crossing with spans. The horizontal floor is suspended from the cables by means of a series of vertical supports. The extremities of the cables pass over piers or posts whose height measures, so to speak, the ordinate of the parabola at the starting point. This sort of bridge was much in favor half a century ago, and its technique is so well known that one may be sure of giving it a sufficient rigidity. From a military standpoint we know that troops and material can pass over it, provided the foot soldiers do not keep step and the wagons are not allowed to accumulate thereon.

When, however, it is a question of military applications, that is to say, of the rapid establishment of a crossing by means of a light material, the parabolic cable bridges lose nearly all their advantages. The installation of the shore piers is difficult, and the anchorages to the abutments are so much the more precarious in proportion as the traction is exerted more vertically.

The gravest inconvenience resides in the impossibility of obtaining sufficient stability in such a system, for which the ratio of the accidental supercharge to the dead weight of the bridge is much too great, in consequence of the necessity of having an easily transportable material. Under the action of the loads that cross the bridge, the conditions of equilibrium vary at every instant, and, as the elements of the structure are indistortable, there results for each position of the load a particular form of equilibrium of the whole, that is to say, a new distortion. In consequence of the tendency of the different points of this flexible system to return to their primitive position of equilibrium by a series of oscillations, it will be seen that in addition to the successive distortions that it will have to undergo, the bridge will be submitted to a vertical tremulous motion, which the light structure of the flooring is ill adapted to resist. These rapid considerations permit of the conclusion that bridges of this kind are not adapted for military applications, because of their dangerous mobility and the difficulty of establishing them.

BRIDGES UPON CHAINS.

Nothing simpler than these could be imagined. It suffices to stretch properly from shore to shore two chains, and to lay the flooring directly thereupon. As the traction is exerted horizontally at the anchorage points, it is easier to obtain strong attachments; but, on another hand, however strong be such traction, it cannot reduce the pitch beyond all limits, and, when the span reaches forty meters, the pitch is such that the flooring will be strongly incurved, and this sometimes renders the passage of it difficult to carts.

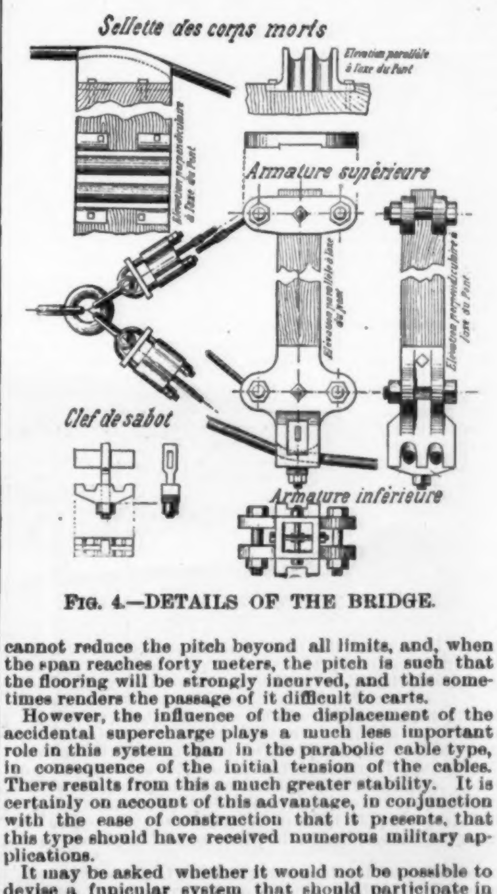


FIG. 4.—DETAILS OF THE BRIDGE.

However, the influence of the displacement of the accidental supercharge plays a much less important role in this system than in the parabolic cable type, in consequence of the initial tension of the cables. There results from this a much greater stability. It is certainly on account of this advantage, in conjunction with the ease of construction that it presents, that this type should have received numerous military applications.

It may be asked whether it would not be possible to devise a funicular system that should participate in the advantages of the two types that we have just examined, and devoid of their principal inconveniences.

The efforts of the builder should tend toward the construction of a true trussed bridge, for which it is not necessary to exclusively employ ropes, which do not lend themselves to tractive stresses, while local re-

sources will, in most cases, permit of improving rigid elements capable of working by compression.

The simplest solution would be to construct an inverted truss with a certain number of pendent joggle-pieces sustained upon cables, which, with them, form an indistortable reticulated system.

This process, which theoretically seems perfect, does not take sufficient account of the special exigences which, in this particular case, arise from the mobility of the load. Under such conditions we cannot consider the materials employed as inextensible, and this renders impossible a definite regulation. The load in moving along the flooring causes the latter to take on a variable curvature, and the stresses that result therefrom upon the different pieces may likewise undergo abrupt variations of intensity and even of direction. Nothing is more prejudicial to the preservation of the assemblages. The bolts, and even the rivets, pulled successively in the two directions, finally begin to play in their recesses and quickly undergo a wear. Besides, in the combinations employed, it should be seen that the stresses are not too suddenly transmitted from one element to the other of the trussed girder, for, in this case, practice teaches that it is necessary to give the pieces a resistance double that which would be sufficient for them if the load acted progressively.

As may be seen, the problem is more complex than it would seem at first sight. A very distinguished government engineer, Commandant Gisclard, has been endeavoring for a few years past to get around these difficulties, and has devised some types of rope footbridges that are capable of rendering genuine service, even outside of cases of war.

The first type devised and experimented with in 1888 by the commandant may be classed with as much reason in one as in the other of the two classes of suspension bridges that we have just examined in succession. It is a parabolic cable bridge in which the cables are wholly situated beneath the plane of the ground. The flooring, instead of being suspended from the cables, is supported above them by compressed pieces.

On another hand, the entire system is very taut horizontally, as in the case of the chain bridge. The pieces serving as supports to the flooring are wooden ties spaced four inches apart. Their uprights are provided beneath with a stirrup which rests upon the cables.

In order to maintain the verticality of the uprights and the rigidity of the whole, there is arranged between two consecutive uprights four stays in the shape of metallic cables united at the level of the flooring by rings of forged iron, so as to form a triangular reticulated system. The stays attached to the extreme uprights are tautened by means of pulleys fastened on the back to the anchoring posts of the parabolic cables. Since the abutments, as may be seen, have to undergo merely horizontal tractive stresses, they are easily established.

The upper guys are each formed of a single cable 20 mm. in diameter and weighing 1·7 kilogramme to the running meter.

The accompanying figures will permit us to dispense with a completer description of the arrangement adopted by Commandant Gisclard.—*Le Genie Civil.*

CRANKS SET ON AN ANGLE.

To have a connecting rod work to the best advantage, especially when a pair of crank arms are to be driven in this manner, it is important that the crank shafts stand perfectly parallel with each other and that the crank pins are both in line with them, for the least inclination in either of these four elements pertaining to a connecting rod will bring some of the bearing surfaces out of true before the crank arms can make a complete revolution. Another condition that every engineer takes an interest in lies in having the central line of the rod stand square with the crank pins as well as bringing all the load where it will center on the bearing surfaces, for then there can be left a little side play without danger of the rod chucking first to one end of a crank pin, then to the other. But there are places where an engineer cannot have all these good running qualities to his liking; there is a dead center to be looked out for, and to make room for three connecting rods to be working on the same shafts at the same time each of the rods must be prepared to work under the conditions shown in Fig. 1,

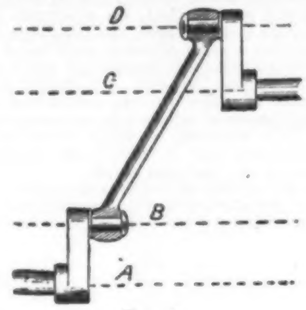


Fig. 1.

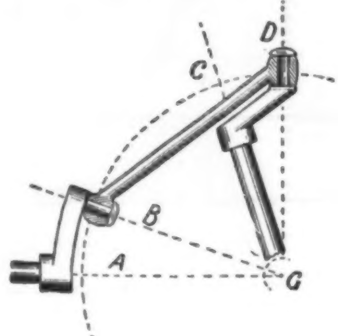


Fig. 2.

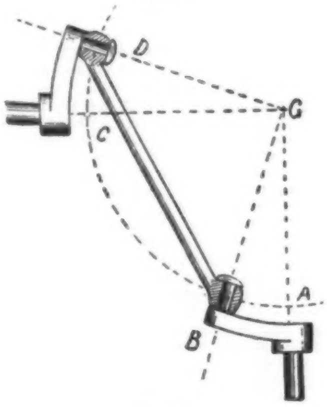


Fig. 3.

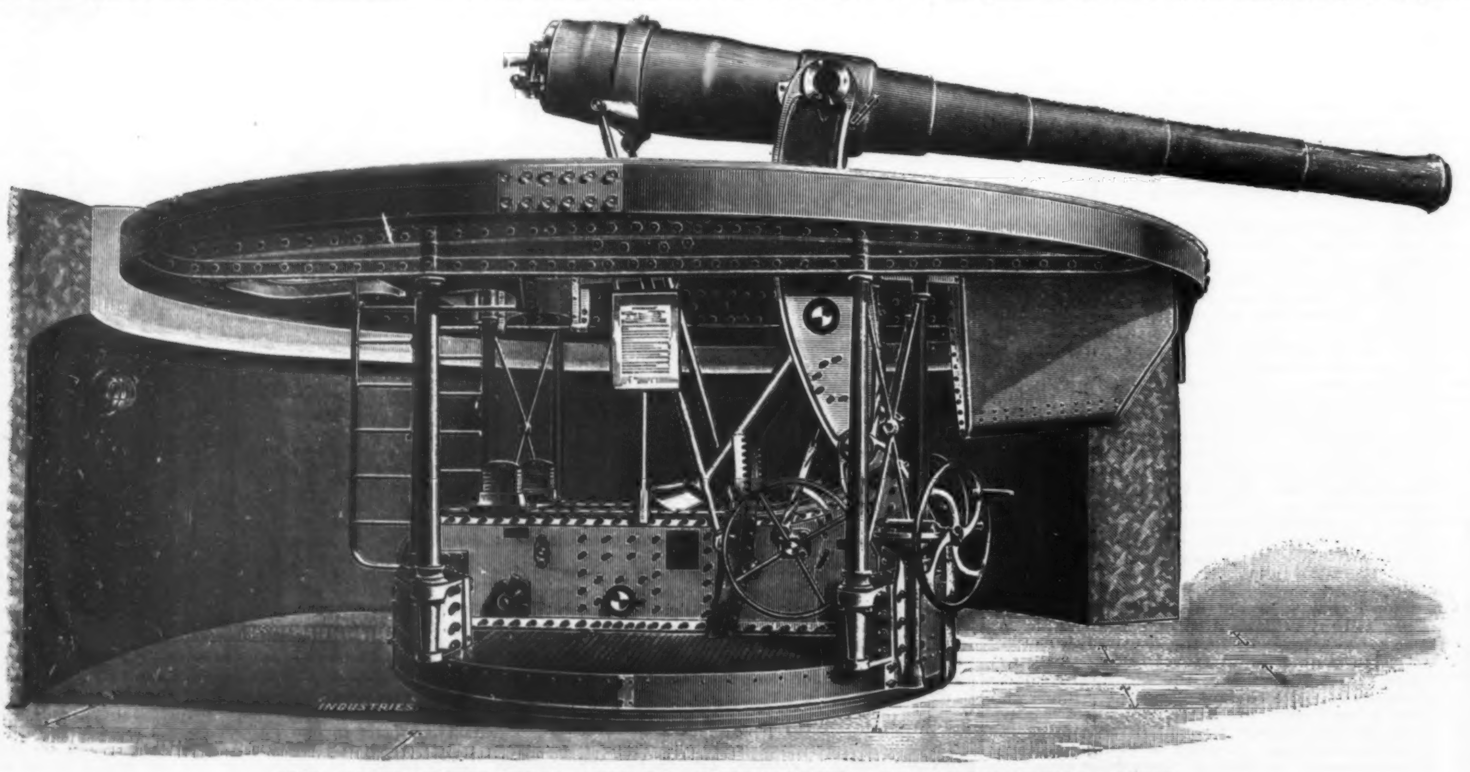
where the pull and push on the rod brings about as much work on the shoulders of the pins as on the bearings themselves; but as long as the central line of the shafts, A and C, are parallel, and the crank lines, B and D, are parallel with them, the connecting rod must be as free and easy in its bearing in one position as in another. If we were to consider these four central lines as radial lines from some far-off center at infinity, the whole system would be but a case where the spherical surface of bevel gears is made use of, and there would be nothing to hinder setting the shafts around where they will meet at an angle from the point, G, as shown in Fig. 2, provided that the central lines of the crank pins, B and D, be arranged to meet at the same point; then it will be seen that no matter where either of the crank shafts be turned, the crank pins must be pointing at the line of centers in every position. Now hold one of the crank arms still and uncouple the rod from the other, and see what the rod will do when turned about on the crank pin. It will carry the loose end around in a circle every point of which will be an equal distance from the center, G, holding the eye always in line with the same center. Now, as both the crank pin and the bearing in the rod are always to be found at the same distance from the line of centers, and lining up in the same direction, they must be as free from any binding action while working on an angle as when laid out on the parallel system. By bringing the inside crank arm around where it can come on the other side of the rod, we can get this method in the form shown in Fig. 3, which admits of keeping all the central lines on the same point of centers. There is nothing to hinder turning the shafts either with or against each other, only the velocity ratio will be quite different in different portions of a revolution. The two dead centers in this means of driving calls for another connecting rod to help over these weak places, or a few gear teeth to assist at the right moment, which we will next investigate.—*Boston Jour. of Com.*

SIX-INCH FIVE-TON HYDRO-PNEUMATIC DISAPPEARING GUN.

We illustrate below one of the largest exhibits of Sir W. G. Armstrong & Co., limited, at the Royal Naval Exhibition, viz., the 6 inch five-ton gun, mounted on an Elswick hydro-pneumatic disappearing mounting. The illustration is reproduced from a photograph of the actual gun and mounting as it appears in the exhibition.

Before describing the hydro-pneumatic mounting exhibited, it may be pointed out that it is specially designed for land purposes, and that by its adoption not only is the cost of protecting coast defense guns very considerably reduced, but at the same time the actual protection is greatly enhanced. At Gibraltar and Malta protected barbettes were adopted for the 100-ton muzzle-loading Elswick guns, and at Dover the 80-ton muzzle-loaders, popularly known as "Woolwich infants," are placed in a turret; but although a certain protection is thereby provided, they form conspicuous targets, and the men working the guns run considerable risk from the firing of machine guns. The "armored cupola" is a decided improvement upon either the "barbette" or "turret." It is practically a mushroom-shaped turret, constructed of large blocks of chilled cast iron, having a profile of a design best calculated to deflect striking projectiles. The most notable instance of its adoption is at the Italian forts of Palmaria, in the Gulf of Spezia, but some idea of the costly nature of these structures may be obtained from the fact that, to mount a 120-ton gun, a proceeding contemplated by the Italian government, a cupola weighing 2,050 tons will be requisite. Then, again, an armored cupola does not afford absolute protection to a gun, for at the Palmaria fort a gun of 46 ft. length has 20 ft. of its length exposed to the enemy's fire.

The disappearing system adopted by the Elswick Ordnance Department thus appears to have important advantages. Instead of an erection above the surface being required, a circular pit, constructed without a disturbance of the ordinary outline of the neighborhood, is provided, and thus the position of a gun is only visible at the moment of firing, as, by the adoption of reflecting sights, it can be approximately trained and laid for elevation before it is raised—the recoil causing it to descend again. It was found impracticable to sink the mounting exhibited in a pit, but this lack of realistic detail is not important. Evidently the protection afforded by the disappearing system, even



SIX-INCH FIVE-TON HYDRO-PNEUMATIC DISAPPEARING GUN.

against accurately aimed shots, consisting as it does of an unlimited thickness of the ground external to the pit, is greater than that afforded by any ordinary armor plates. The light shield overhead has been added as a protection against fragments of shells or *debris* which might otherwise fall into the pit. The disappearing system makes it easy to obtain perfect security for the magazines, and in tropical climates underground living rooms for the gunners have been found to be very suitable.

Reference has already been made to the "cupola" and "turret" systems of protection. About three years ago, at Bucharest, it was demonstrated by actual gunnery trials that neither system sufficed for protection against even very ordinary six inch guns, although the latter was struck three times for every twice that the cupola was hit. At Portland, in 1885, the disappearing system was tried, and, although H. M. S. Hercules fired 176 shots at a dummy gun mounted on a disappearing carriage, which appeared at certain intervals for two minutes, a puff of smoke indicating its position, not the slightest damage was done to the gun and its mounting.

The total weight of the shield, the carriage, and the gun exhibited is about 14 tons, the whole resting on a movable turntable, so that the gun can be trained to fire in any direction. The gun is carried on a pair of heavy arms or levers, in which the trunnions rest. It is elevated to the firing position by a hydraulic cylindrical press, placed on an incline in the center of the carriage, compressed air being stored in a chamber on the exterior of the cylindrical press in which the ram works. At the bottom of the air chamber there is a quantity of liquid, which, when the gun is to be raised, is driven by the pressure of the air into the hydraulic press, and forces out the ram, the gun being simultaneously raised. After firing, the liquid is driven through recoil valves back into the air chamber, and re-compresses the air to a pressure of about 1,250 lb. to the square inch. The passage of the liquid from the air chamber is governed by a hand valve, so that the gun can be raised when desired. As the ordinary recoil arrangements depend upon the gun being fired, special arrangements have had to be made for the lowering of the gun and carriage at the exhibition.

Over 220 hypro-pneumatic disappearing carriages have been manufactured at the Elswick Works for guns up to 67 tons weight, and supplied to the British Home and Colonial, Japanese, Chinese, Italian, and Siamese governments, and, despite the most stringent tests, these disappearing carriages have always worked without the slightest hitch.—*Industries.*

THE DISTILLATION OF MOLASSES.*

By CHARLES DEBREMOND.

HAVING practiced in France, for several years, the distillation of alcohol from beets and of brandy, when I came to this country I was struck at the practicability of distilling the scums of sugar houses, which were thrown in the ditches. I vainly tried to start a small distillery to utilize these scums, which were a total loss for the planter, before the general use of filter presses. Failing in this, my attention was directed for some months past toward the cheapness of our common molasses for distilling purposes. I found many sugar planters ready to adopt my views, but anxious to know the result of the discussion on this subject, by your association, before deciding. I cannot find a better opportunity to express my ideas, than before the ablest body of sugar men in this country; and without discussing at length the various aspects of the question, I desire to expose a few points which, I hope, will perhaps help you in determining whether this new industry will pay.

Gentlemen, the yearly increasing production of inferior molasses, together with the decrease of its value as a food article, makes imperative the finding of some new way of disposing of this product. Without discussing the other processes recently suggested, I am satisfied its transformation into alcohol will offer to the planter the best inducement to reap some profit from this now valueless article. For the last two years the price of Louisiana molasses has been low enough to justify its distillation, while the question has only been brought to a serious consideration for the past two or three months. It is not surprising that any one should have attempted sooner the distillation of this raw material, owing to its previous high value, too high to give satisfactory returns. But now the time has come, and whereas the price of our molasses has diminished, the price of corn has steadily advanced, giving the advantage to our produce. The scarcity of grain now prevailing throughout Europe seems to point out that these high prices will be maintained for some time to come, and the general outlook is very promising for the starting of this industry in Louisiana.

The distillation of molasses is nothing new; all over the sugar-producing countries of the world it is practiced; and with a full knowledge of this old industry, we can ourselves embark in this venture, without the uncertainty attending the other new modes suggested for the use of our molasses. The only question which arises is to determine if, as a raw material for the production of alcohol, it can compete with corn, so extensively used in the western distilleries.

The grain distilleries get a larger profit by using the residues of their corn for feeding purposes; but, as with molasses the manipulations are much more economical and the spirit of a better quality, we are in position to hold our own end with them. As I understand it, the Louisiana molasses distilleries are not intended to be exclusively industrial plants, buying at the market's quotations, their raw material overloaded with the cost of barrels, freight, commission, gauging, etc., but must be, like in the West Indies, considered as an annex to the large sugar houses, whose aim shall be the distillation of their own molasses and those of their neighborhood. They shall be operated on the same principles as the central factories; and thus managed, will be in better condition than the northern or western molasses distilleries.

The internal revenue records value for the last fiscal year the average yield in the United States of proof spirit* from one bushel grain at 4·27 gallons, and from one gallon molasses (chiefly Cuba molasses) at 0·754 gallon. It requires, therefore, 5·65 gallons molasses to yield in proof spirit the quantity given by one bushel grain. Can we from the analysis of our common molasses hope for so large a yield?

In some experiments on various samples, I have distilled from 58 to 67 per cent. proof spirit. In Jamaica the yield of rum from one gallon molasses is about 0·600 proof gallon; in Spain, of 0·650. In France, which is a large producer of alcohol, the average yield of a gallon beet molasses with 44 per cent. sugar is 0·500 proof gallon.

The analysis of a sample of molasses from Mr. John Dymond's Belair plantation, from which I have distilled 58 per cent. proof spirit, showed:

Sucrose, 32·60 per cent.; glucose, 24·27 per cent. = 56·87 per cent. sucrose and glucose. This yield, based upon the above percentage of sugar, and compared with the average yield of beet molasses, would be 0·645 proof gallon.

The above molasses is very poor; in fact, with as little sugar left as in any molasses produced by the country refineries, with the usual processes of manufacture. But if we were to get, for distilling purposes, molasses showing 36 per cent. sucrose and 25 per cent. glucose = 61 per cent., such as was the analysis of another sample (from the Lafourche Refining Company), when the yield in experiments was 67 per cent. proof spirit, the theoretical yield would be 0·698 proof gallon; or an average for Louisiana common molasses of 0·669 gallon from one gallon molasses. This yield would fall 0·085 below the New England molasses distilleries' yield.

It seems, therefore, that it would require 6·38 gallons of our molasses to yield in proof spirit the quantity given by one bushel grain. The table here below gives the value, as raw material, of a gallon molasses, based upon the yield of 0·669 proof gallon, comparatively with a bushel grain valued from $0.26 to $0.35.

every distillery should be equipped for the production of raw spirits and of neutral alcohol; we would then be able to manufacture what would pay best.

An advantage of distilling our molasses is that whereas it cannot be kept for a long time without being spoiled by the fermentation, the spirit improves by growing old, and can be kept in bond for three years before the tax becomes due. Another advantage of a distilling plant would be to facilitate the saving of frost-bitten canes, which must be disposed of without delay. Every Louisiana planter knows, by experience and to his expense, how fast frozen cane will lose its sugar properties. The juice remains nearly as valuable for distilling purposes. Here is the yield of a ton of canes distilled, with a mill extraction of 70 and a richness of 13·50 per cent. sucrose and glucose or 190 pounds sugar.

Absolute alcohol 14·15 gallons, or about 28 proof gallons.

The yield in sugar would be:

Sugar, 160 pounds at 5c.	$8 00
Molasses, 4·5 gallons at 5c.	23
	$8 23

The price of the distillate ought to be 29 cents for proof gallon to net to the planter the same price as sugar. But the alcohol from sugar cane is nearly of as good a quality as the alcohol from the grape, and far superior in taste to that of grain, and we may reach 29 cents for a fine article. We can perhaps, too, find some advantage by mixing with our molasses in the mash tubs the cakes of exhausted scums and get some alcohol from the sugar left by the filter presses.

I do not wish to discuss at length the efficiency of the several apparatuses which can be used in a well managed distillery, every kind having its merits, but to impress briefly upon your minds a few points which, in the choice of a still, I know from personal experience may be of some value.

In Europe and the West Indies the continuous sys-

Value of the bushel grain, cents	26	27	28	29	30	31	32	33	34	35
Value of the gallon molasses, cents	4 1/16	4 1/4	4 3/8	4 9/16	4 3/4	4 7/8	5	5 3/16	5 5/16	5 1/2

What is the value of this same gallon molasses when distilled, the price of proof spirit in bond valued from 19 cents to 25 cents:

tem is highly esteemed. These apparatuses, now nearly perfect, operate automatically and with quickness, and are the best thing to be had when the dis-

Value of the gallon proof spirit, cents	19	20	21	22	23	24	25
Gross value of the gallon molasses, cents	12 5/8	13 3/8	14	14 3/4	15 3/8	16 1/16	16 3/4

In valuing the proof spirit at from 19 to 25 cents, it must be remembered that the spirit from cane molasses is, compared with the grain spirit, of a superior quality, and this price can be reached. If the distillery were able to get some cane juice, to be mixed with molasses, and to manufacture good rum, the price would be increased from 5 to 8 cents per gallon. The price of new Jamaica proof rum is about 40 cents. At the figures ruling now on the market, the distillers net 45 cents per gallon alcohol, or 23 or 24 cents per proof gallon.

I will now establish the cost of running a distillery working 500,000 gallons molasses, with a daily capacity of 2,000 gallons, yielding 1,335 gallons proof spirit; and the margin left to the planter by the sale of 334,000 gallons spirit, compared with the amount netted by 500,000 gallons molasses sold on the New Orleans market, at the last year's average price of 7 cents. Deducting $2.50 per barrel ($1.50 for barrel and $1.00 for freight, commission, etc.), the net value for the planter has been reduced to 2 cents per gallon; for 500,000 gallons to $10,000.

The cost of erecting a distilling plant of the above capacity will reach about $12,000, with a large part for the buildings and incidental expenses, the value of the machinery not exceeding $7,500 or $8,000; and the amount for running the same will stand as follows:

Interest of the capital invested, insurances, repairs, etc.—20 per cent. on $12,000	$2,400
Fuel—30 barrels coal daily at 35 cents per barrel for 250 days	2,600
Yeast, acid, lights, oils, etc.	3,500
6,700 barrels at $2.25	15,705
Freight, commission, gauging, etc. ($1.50 per barrel) on 6,700 barrels	10,125
Management and workmanship ($1.10 per barrel)†	7,425
Total in round numbers	$42,000

Amount of the sale of 334,000 gallons proof spirit, and net value to the planter of one gallon molasses:

tillation of raw spirits is the main object. But if you wish to produce neutral alcohol, this process will not do the work as satisfactorily. With a single operation, by the addition of some mechanical provisions, high test spirit can be produced, as high as 180 to 185 deg., but not neutral alcohol. The neutral alcohol requires absolutely redistillation, which cannot be done economically by the continuous process. Furthermore, the fermented beer seeding the apparatus and flowing out automatically and continuously is not always entirely exhausted. The height of the column in most of the continuous apparatuses, with its 18, 20, 25, and even more plates, offers a large surface to the cooling atmosphere at the expense of fuel, besides the time required to clean the same.

The intermittent apparatuses, as constructed to-day, possess all the desirable features of the continuous process, save, perhaps, a little less quickness in doing the work, and generally overcome the latter's defects. The cleaning is easier, and the flow of spent beer being regulated at will by the distiller, the alcohol from the fermented juice can be entirely exhausted before being allowed to flow out. The heating is also more easily regulated.

As to the way of applying the heat to the apparatus, I would never advise the use of the naked fire, excepting with very small stills. A still heated by steam will always realize a notable reduction in the cost of fuel; and, as a distillery of 500 or 600 gallons molasses capacity needs a boiler to run its pumps, the saving in fuel would soon repay the cost of a larger boiler. Everybody knows how inconvenient it is to superheat in the fabrication of sugar; in the distillation of spirits these inconveniences are still more perceptible, and the heating of a large still by direct fire requires the constant attention of a skilled fireman to avoid the empyreumatical flavor which spoils the careless distilled spirit, from beer holding in suspense a large proportion of solid matters.

I have seen and critically examined the drawings of some apparatuses manufactured by Gannon's copper works, of Jersey City, and I find these apparatuses to

Value of one gallon spirit	$0 19	$0 20	$0 21	$0 22	$0 23	$0 24	$0 25
Gross value of 334,000 gallons	$63,000	66,000	69,000	72,000	75,000	78,000	81,000
Net value of 334,000 gallons	21,000	24,000	27,000	30,000	33,000	36,000	39,000
Net value of one gallon molasses	4 3/16c.	4 3/4c.	5 7/16c.	6c.	6 5/8c.	7 3/16c.	7 5/8c.

In the above calculations I charge to the debt of the spirit $2,400 for interest of the capital invested in the plant, and this same item does not figure to the debt of the molasses sold on the New Orleans market, which, however, should be charged for its share in the interest of the capital invested in the sugar house where it is produced.

It can be so safely deducted that as far as the yield is concerned, we cannot compare with advantage with the northern molasses distilleries, but being situated in the very center of producing country, we are far better located for our supply of raw material.

My information in regard to the finding of a home market for our spirits is very limited, but I have been told Mexico and Central America can be relied upon as large consumers of the product. On the other hand the consumption of alcohol by compounders and by the drug trade is very important in New Orleans, the latter using yearly thousands and thousands barrels. I know positively, from an interested authority, that we can readily furnish the wholesale druggists with their supply of alcohol. In my opinion,

meet all the requirements needed for an effective work. I refer specially to two apparatuses, one for distillation and redistillation of deodorized alcohol, and the other, which is an improvement of the old patterns of Laugier and Darosne, for the distillation of high testing and well flavored spirits.

I will add a few words in regard to the government's inspections. The internal revenue regulations are considered very annoying, not to say prohibitory; but if these regulations do not interfere with the work of the western and northern distillers, I cannot understand why we, here in the South, cannot manage our distilleries in compliance with their provisions. Enacted to protect the internal revenue, there is nothing in them which can be a nuisance to the management of a legitimate business. Far from this, their very strictness compelling the distiller to obtain the best results from his raw material, his fabrications must be carefully done, giving so the advantage of larger returns to the treasury and to himself. It is my earnest belief that the United States officers do not invoke their large powers to annoy the distiller, but are as liberal as possible in the discharge of their duty, as long as they are satisfied that it is not the purpose of the manufacturer to defraud the government.

When we will be able to transform our 500,000 barrels molasses, produced every year, into 17,000,000 gallons proof spirit, paying to the United States taxes amounting to $15,000,000, there will be perhaps a little less objections raised against the granting of a bounty

* Section 3249, Revised Statutes of the United States, provides that proof spirit on which a tax of 90 cents shall be levied and collected shall be held that alcoholic liquor which contains one-half its volume of alcohol of a specific gravity of 0·7939 at 60 deg. Fahrenheit.

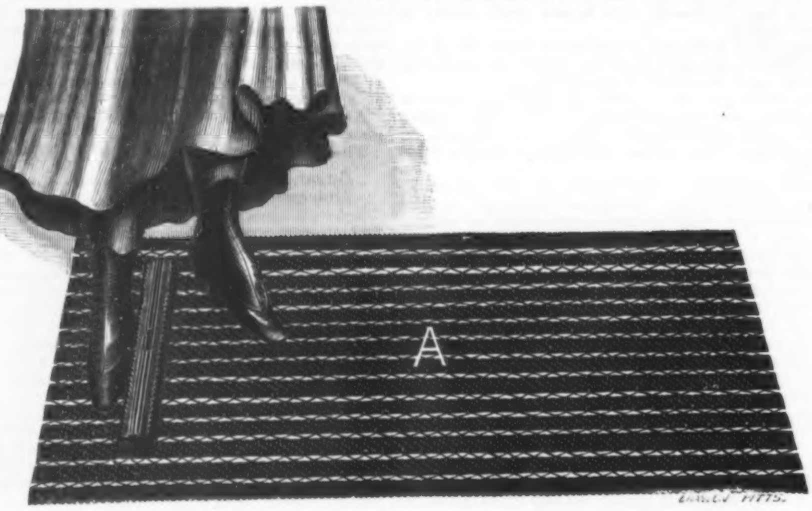
† In France and the West Indies the cost of workmanship is about 1 cent per gallon spirit, but owing to the higher wages paid in this country, I charge 2 1-5 cents per gallon to this account. The exact cost can be determined only after actual working of the distillery, and may fall below the estimate.

* A paper by Mr. Charles Debremond, read before the meeting of the Sugar Planters' Association, September 12, 1891.—*La. Planter.*

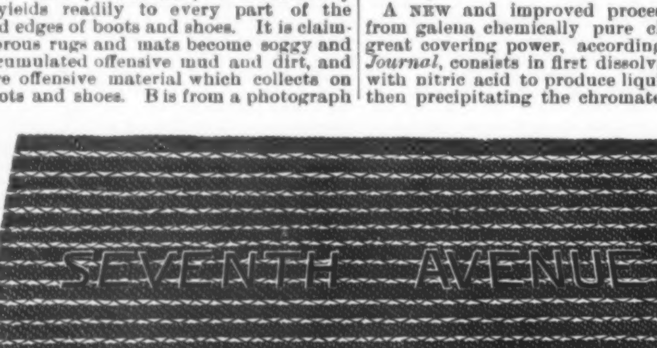
to the sugar producers, and we will find ourselves far better fitted for claiming authoritatively the protection to which is entitled an industry so largely increasing the internal revenue's income.

IMPROVED WIRE MAT AND INDOOR WIRE RUGS, STAIR CARPETS, ETC.

The illustrations show an outdoor mat, A, provided with a rubber serrated rubber 1 attached to the wire by

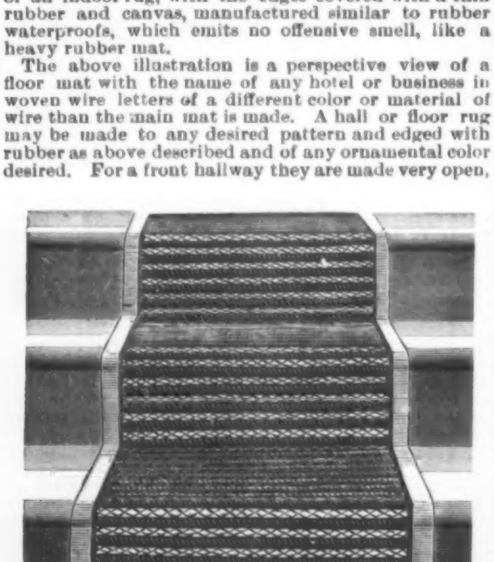


means of brass screws and washers from underneath, which screw up into the rubber, which is of a fibrous mixture which holds firmly to a wood screw as if it were of best quality of wood. This rubber or boot and shoe cleaner is mildly vulcanized, so that it is very flexible and yields readily to every part of the soles, heels, and edges of boots and shoes. It is claimed that all fibrous rugs and mats become soggy and musty from accumulated offensive mud and dirt, and even other more offensive material which collects on the soles of boots and shoes. B is from a photograph



of an indoor rug, with the edges covered with a thin rubber and canvas, manufactured similar to rubber waterproofs, which emits no offensive smell, like a heavy rubber mat.

The above illustration is a perspective view of a floor mat with the name of any hotel or business in woven wire letters of a different color or material of wire than the main mat is made. A hall or floor rug may be made to any desired pattern and edged with rubber as above described and of any ornamental color desired. For a front hallway they are made very open,



the intermediate wires being corrugated and forming loops or small eyes of equal distances apart, so that the coils of wire intersect these loops, which hold the coils apart, so that the rug lies flat and loose on the floor with no fastening whatever. A floor may be covered with a very cheap, high-colored oil cloth and this wire rug placed over it, which presents a very rich appearance, and can be lifted and rolled up, taken out and either shaken or washed with a hose, the oil cloth wiped off and the hall is cleaned in a few minutes, and no dust accumulation, as with any other carpet known. As a sanitarian it has no equal.

One of the cuts shows a stair carpet made in the same way as the hall carpet with oil cloth under it and is held in place or detached and removed as easily as any other carpet made.

For further information address Emerson & Abidgley, patentees, Beaver Falls, Pa., U. S. A.

PROCESS OF MAKING CHROME YELLOW.

A new and improved process for manufacturing from galena chemically pure chrome yellow having great covering power, according to the *Paper Trade Journal*, consists in first dissolving pulverized galena with nitric acid to produce liquid nitrate of lead and then precipitating the chromate of lead by subjecting the nitrate of lead to the action of bichromate of potassa, neutral chromate of potassa or chromate of potassa soda.

The galena (sulphuret of lead) is first pulverized by suitable means, and in case it contains foreign minerals or other impurities it is washed or otherwise treated in a suitable manner to remove the minerals or other impurities. The pulverized galena is then placed in vessels of wood or other suitable material, and is therein dissolved by adding nitric acid diluted in water, the entire mass being stirred by suitable means actuated by hand or other motive power. A slow dissolving takes place at the ordinary temperature, but when it is desired to further the dissolving process, the mass is heated artificially either by heating the vessel containing the mass or by using hot water added to the nitric acid or by the use of steam. The product obtained is nitrate of lead in a liquid state.

The quantity of nitric acid necessary for dissolving a certain quantity of galena depends on the percentage of lead contained in the ore and to a certain extent on the amount and nature of impurities contained in the galena, and also on the length of time in which the dissolving takes place. In treating one hundred pounds of galena having eighty per cent. of metallic lead about ninety to one hundred pounds of nitric acid of 36 deg. to 38 deg. Baume are used, and the nitric acid is diluted with one hundred to two hundred pounds of water. This mixture is left for from about twenty-four to thirty-six hours, and is stirred up occasionally, as above stated.

After the galena is dissolved by the nitric acid and the sulphuret of lead is changed into liquid plumbic nitrate (or nitrate of lead), then the sulphur which floats occasionally on the surface of the solution is removed and the substance which remains undissolved is washed out and is also removed. The liquid nitrate is then passed through filters of suitable material, such as felt, linen, hemp, flannel, etc., or is left standing for from twelve to eighteen hours, for settling and clearing.

Now, in order to produce the chrome yellow from this nitrate of lead, bichromate of potassa is dissolved in water, and a sufficient quantity of this solution is poured into the plumbic nitrate solution until all the plumbic nitrate is changed into chromate of lead, called "chrome yellow."

Instead of the bichromate of potassa, neutral chromate, or chromate of potassa soda may be used, and, for the purpose of obtaining lighter tints, they may be tempered with sulphuric acid or any other compound of sulphur. The liquid nitrate of lead is placed, preferably, in large, open receptacles of wood, clay, earthenware, or other suitable material, and the chromate of potassa solution is placed in similar vessels and then placed above the receptacles containing the plumbic nitrate. The chromate of potassa can then easily be run into the lower receptacles containing the liquid nitrate of lead, and this mixture is constantly agitated by suitable means until all the plumbic nitrate is changed into chromate of lead, which is precipitated on the bottom of the larger receptacles.

The chemical action which takes place by this changing of nitrate of lead into chromate of lead is that the chromic acid of the potassa assumes the place of the nitric acid, which parts from the lead and assimilates with the potassium, so that the lead as chromate of lead is precipitated on the bottom of the receptacle, while the nitric acid of the plumbic nitrate remains with the potassium, which latter has parted with its chromic acid and a quantity of water as solution above the chromate of lead.

To change the nitrate of lead recovered out of the one hundred pounds of galena above mentioned into chromate of lead about fifty-six pounds of bichromate of potassa are used. This change usually takes place in from about ten to thirty minutes, after which the chrome yellow (chromate of lead) is left for a few hours to settle, and then the solution standing on top of the chrome yellow is drawn off by suitable means or run out of the vessel by opening a cock or cocks placed above the level of the chromate of lead.

The latter is then washed by adding pure water, which is poured upon the chrome yellow, and the mixture is stirred up by suitable means, so that all the remaining liquid nitrate of potassa is removed from the chromate of lead. After this is accomplished the mass is left to settle, and the water is again drawn off from the chrome yellow, which then settles on the bottom of the receptacle. This washing is repeated as often as is deemed necessary.

The chrome yellow is next placed in suitable receptacles and dried in the open air or in specially constructed drying rooms, after which it is packed in boxes, kegs, etc., and is then ready for use. The liquid nitrate of potassium or saltpeter lye removed from the receptacles in which the chrome yellow is precipitated, and the first water used for washing the chrome yellow, as above described, are placed in large, open, flat receptacles or excavations, so as to be exposed to the action of the air and sun, or the liquids may be operated on by a small graduation work, so that a great portion of water evaporates. The residue is then heated in suitable vessels or troughs by a slow heat until a salt crust is formed, which, when cooled off and left to dry, is nitrate of potassium or saltpeter in a pure state.

From one hundred pounds of galena having eighty per cent. metallic lead from twenty-eight to thirty pounds of pure and dry saltpeter are produced by the above described process. The sulphur produced by the dissolving of the galena by nitric acid is melted in a small stove or furnace in the usual manner and then refined, so as to produce bars of sulphur called "brimstone." About ten pounds of such sulphur are produced from one hundred pounds of such galena treated in the manner described.

The chrome yellow thus produced is said to be chemically pure and of great covering power, equal to the best chrome yellow in the market.

The process is very simple, and the crude lead ore is transformed into chrome yellow in from three to four days.

THE USES OF CHROMIUM FLUORIDE.

By M. Th. Stricker.

The new salt, chromium fluoride, proposed by Messrs. R. Koepp & Co. as a substitute for chromium acetate in calico printing, etc., is a green crystalline powder, containing 60% anhydrous fluoride of chromium and 40% water of crystallization, having the formula $Cr_2Fl_6 + 8 H_2O$.

Comparative trials have been made with chromium acetate, prepared by dissolving chromium hydrate in acetic acid. This acetate, upon analysis, was found to contain 8·28 per cent. of chromium oxide (Cr_2O_3). That is to say, 20·5 per cent. of the acetate $(Cr_2C_2H_3O_2)_4(OH)_2$, which is equal per kilogramme of acetate to 118·5 grammes of the anhydrous fluoride, or to 197 grammes of fluoride of 50 per cent.

This 197 grammes of fluoride give 1 kilogramme of a solution of 170° B., or, in other words, a solution containing 245 grammes per liter.

The results of the experiments made upon its printing capabilities show that the shades produced by the acetate are both purer and deeper. This difference is probably due to the presence of hydrofluoric acid, to which alizarine is very sensitive. The following color has been printed on both prepared and unprepared tissues:

55 grammes alizarine violet.
45 c.c. acetic acid.
2-10 liters alizarine paste.
30 grammes chromium acetate at 16° B.

Another was printed, using 30 grammes of fluoride at 17° B.

The shades produced by the acetate were of a beautiful rich purple color, while those of the fluoride were yellowish, and not so bright.

The difference was still greater with ceruleine, but not so marked with alizarine blue, "Graine de Perse," and anthracene brown.

Other trials have been made in the following manner:

Acetate of chromium at 16° B. was printed with three parts of gum adracanthe, steamed, fixed in strong sodium carbonate (150 grammes to liter at 70° C.), and washed.

The same was repeated with fluoride at 17° B.

Another portion was fixed direct in sodium carbonate without steaming.

Oxide of chromium, when fixed by means of the fluoride, is brighter. The steaming, previous to passing through the sodium carbonate bath, is not an essential in the case of the fluoride; whereas, if the acetate is employed, the omission of the steaming operation results in the oxide being but partially fixed.

In this way strips of material were printed with chromium oxide, fixed in a similar manner, and were dyed in gallocyanin, anthracene brown, "Graine de Perse," nitro-alizarine, alizarine blue, alizarine black, and alizarine.

With all these colors it was equally stable; there being but little difference between the shades obtained by the acetate and fluoride methods respectively. The difference between those of the acetate, with and without steaming, was considerable; while, with the fluoride in, it was less noticeable.

The fluoride has, lastly, to be tried as a mordant in dyeing, by steeping in fluoride drying, steaming, fixing in a soda bath, and dyeing.

Comparative trials were made with a corresponding quantity of acetate, and with a mordant of an alkaline chromate, containing a similar quantity of chromium oxide.

The shades, with the alkaline chromate, were brighter than those obtained either by the acetate or fluoride, besides allowing a more complete and penetrative action.

The results were likewise in turn better, in the case of the acetate, than with the fluoride; the two first consequently producing a better white in dyeing.

As regards the original cost of the fluoride, it is the same, or nearly so, as that of acetate obtained from precipitated chromium oxide and acetic acid.—*Le Moniteur de la Teinture; Chemical Trade Journal.*

AN AUTOMATIC TEAPOT.

ALL housewives know from experience the difficulties and vexations occasioned by the pouring out of hot beverages, especially when the guests are numerous, the tea or coffee pot is of large size, and it is not desired to entrust the duty to a servant. It was from England, naturally, the tea-consuming country *par excellence*, that a remedy was to reach us for the petty annoyance of domestic life above mentioned. This remedy presents itself under the form of an automatic teapot devised by a Mr. Royle, and the accompanying representations of which render a description almost superfluous.

The apparatus scarcely differs in appearance from an ordinary teapot, save in the form of the spout, which starts from the lower part of the pot and is curved above in order that the jet that issues from it shall be nearly vertical. The cover of the teapot consists of a hollow cylinder forming a piston and provided at the top with a wooden or ivory knob containing an aperture 5 or 6 mm. in diameter. In order to get a cup of tea, it suffices, after placing a cup under the nozzle, to lift the cover by grasping the knob with the thumb and second finger, and then to thrust it back into place with the forefinger over the aperture. As the air that has been introduced through the aperture during the ascending motion of the cover cannot escape, it exerts a pressure upon the liquid, and causes it to flow out through the spout. The flow is at once stopped on lifting the finger that closes the aperture in the knob, as this removes the pressure exerted by the air upon the liquid. It will be seen from this short description that the arrangement is as simple as it is ingenious. The liquid is drawn from the bottom, and may, by successive maneuvers of the cover, be drained to the last drop, without any fatigue and without stirring the vessel from its place.

We would merely recommend those experimenting with the apparatus for the first time to remember to put a cup under the nozzle, so that the tea may not be discharged upon the table cloth—an accident that happened in my presence to a housewife who had invited a few friends to the inauguration of the pneumatic teapot.

AUTOMATIC TEAPOT—A, DETAILS OF THE PISTON.

[NATURE.]

A NEW KEYED MUSICAL INSTRUMENT FOR JUST INTONATION.

ONE of those subjects which periodically turn up for discussion, and then vanish for an interval of neglect, is the possibility of obtaining just intonation in the performance of music. Those who have studied theory, properly so called, know very well that the series of musical sounds commonly used, as expressed on the pianoforte, do not give the true harmonic combinations on which the art is based, and many zealous attempts have been made to cure the evil. One of these showing some novelty and much merit is now exciting the attention of eminent musicians on the Continent; it was mentioned briefly in *Nature* of April 2 last (p. 521), and it may be interesting to many readers to give some further account of its general features. We may, however, preface this with a few words on the state of the question generally.

Although the equal division of the octave has now taken such a firm hold on modern musicians, it is only within a comparatively recent period that its use has become common. It was well known at an early date, but its defects checked its use until the general introduction of the class of instruments which have culminated in the pianoforte; the reason of its adoption then being that the want of sustaining power in the clavecin and the harpischord so diminished the discordant effect as to make the faulty tuning endurable. People then began to get accustomed to it, and it was soon found that the system gave such extraordinary facilities for chromatic music that the cultivation of this style became enormously developed. Hence the chromatic style and the equal temperament have become closely allied, and it is almost a matter of doctrine that the pianoforte division of the octave is a necessary element for the proper performance, or proper understanding, of the compositions of modern days.

For organs, the application of the equal temperament came much later. Down to about the middle of this century they were tuned on a system which gave the most usual keys fairly in tune, at the cost of an occasional harsh chord, which for church purposes was considered but a small price to pay for the general smooth and harmonious effect. But when highly skilled players began to increase, they required the organ to be more used for exhibition, and for this purpose the introduction of the equal temperament was deemed desirable. And so, as it thus commanded the two most powerful sources of music, it crept into use also by stringed instruments, orchestras, and voices, and so it has become general.

The consequence is that, now, practical musicians are in the habit of accepting the equal-tempered intonation as genuine and true music; and as the study of the principles of musical structure is by no means highly encouraged in this country, efforts are seldom made to undeceive them. Students are authoritatively told that questions about just intonation may be interesting to physicists and mathematicians as recondite problems in acoustical science, but that they have no bearing on "practical" music, and that therefore musicians need not trouble themselves about them. Some years ago, at a meeting of one of our musical educational establishments, it was said, "We do not here make music an affair of vibrations"—a sentiment which was received with loud applause.

No doubt some enthusiasts have carried the investigation on this subject to a degree of refinement which far outruns practical utility; and one can have little sympathy with those who delight in reviling and despising the duodecimal scale; seeing that it has been the means of materially advancing the art, and that the modern enharmonic system, founded upon it, has been so thoroughly incorporated into modern music that it is difficult to see how it could be now ignored.

But, on the other hand, one must, if one is to exercise reason and common sense in musical matters, be equally at variance with the party who, arrogating to themselves the title of "practical" musicians, force on us the equal temperament to an extent which really means the extinction of true intonation altogether.

We now, indeed, never hear it, and in fact only know by imagination what a true "common chord" means.

The principal objection to this state of things is that the ears of musicians become permanently vitiated, and lose the sense of accurate intonation, or the *desire to approach it*, which is tantamount to abandoning the most precious feature that modern music possesses—namely, beauty of harmony. A chord of well selected sounds, exactly in tune, is a very charming thing; but is a thing unknown to ears of the present day. I can recollect the time when singers and violin players strove to sing and play in good tune, and the effect of such unaccompanied part singing, and such violin playing, was very delightful. But now, music not being made "an affair of vibrations," one is often ashamed of the quality of what one hears; nobody seems to think purity of harmony, either with voices or violins or orchestras, to be a matter worth striving after.

It is surely a reasonable wish that this should be checked, but one must be reasonable in one's expectations. The pianoforte must certainly be let alone, and so must the organ when used for exhibitional purposes, though its cacophony under the present tuning detracts much from the pleasure of hearing such fine playing as is now common. But vocalists and violin players ought to be encouraged, as of old, to sing and play in tune, and for this purpose what is wanted is an instrument which will keep up and circulate the tradition of what true music means. To attain this, therefore—*i. e.*, to construct an instrument which shall enable a player, with moderate ease, to play polyphonic music, of moderately chromatic character, in strict tune—has been the aim of many ingenious musicians and mechanics.

I need not go into history. Everybody may see at South Kensington the wonderful enharmonic organ, built half a century ago by General Thompson, and may read of the instruments described by Helmholtz, and his voluminous commentator, the late Dr. Ellis; and the efforts in the same direction of Mr. Colin Brown, and of Mr. Bosanquet, who has devoted much attention to the matter, are worthy of all praise. But my object now is to describe the latest attempt of the kind, by a native of Japan, Dr. Shohe Tanaka. Persons who have lately had to do with that country have been well aware, not only of the natural ingenuity of the Japanese, but of the high standing which many of their youth have taken in scientific studies. Dr. Tanaka combines these two qualifications. After an industrious preliminary education in his own country, he went to Berlin, where he has been for five years studying physical and mechanical science under the best professors, and with these he has combined also a study of music. He has published, in the *Vierteljahrsschrift fur Musikwissenschaft* for 1890, a long essay on the subject generally, which fully demonstrates his knowledge of it; and he appears to have made a very favorable impression in Germany. He exhibited his "enharmonium," as it was called, to the emperor and empress, and he produces testimonials from many musicians of the highest rank, among whom are Joachim, Von Bulow, Reinecke, Richter, Fuchs, Moszkowski, the whole staff of the Leipzig Conservatoire of Music, and many others. These not only speak highly of the instrument, but (in strong contrast to the English authorities) earnestly support and recommend the object it is proposed to serve. Indeed, some of the testimonials are essays on the advantage of the cultivation of pure intonation. Von Bulow especially says:

"I have requested the maker to make me such an enharmonium for my personal use at home. I am earnestly desirous to protect myself during the few remaining years of the exercise of my art against constantly possible relapses into already conquered errors. In order to make pure music it is necessary to think in pure tones. It is *de facto* the practically insuppressible conventional pianoforte-lie to which nearly all corruptions of hearing may be traced."

With these credentials the inventor has brought a sample of his instrument for examination in England, and I may proceed to give some idea of what it is like.

The great object to be aimed at is facility of performance. It is in this respect that most of the former instruments have failed; the multitude of notes has generally required a new kind of clavier, or the manner of manipulating them has been so complicated and difficult as to require a special learning attended with much trouble. The present instrument is a harmonium of five octaves, having a keyboard modeled precisely on the usual pattern and size. Dr. Tanaka has greatly simplified the problem by adopting the transposing system, often adopted with pianofortes. Whatever key the music is in, it is played in the simplest of all keys, the key of C, and by means of a bodily shifting of the keyboard to the right or left, it is set so as to act in the key required. It is, in fact, the principle used in the horn tribe; the horn or trumpet player reads and plays his music in the key of C, and the transposition of this to the key required is previously arranged as a part of the mechanism of the instrument; or, rather, as the author puts it, the music may be read and played on the tonic sol-fa system, and he might have adopted the symbols if he had not feared it would be too startling a change.

The points in which the new keyboard differs from the ordinary one are that the black keys are divided, some into two and some into three parts, and one additional shorter and narrower black key is introduced between the E and F white keys. This arrangement gives twenty notes, which suffice for modulating into a reasonable number of keys with sharp signatures.

To provide for modulations into keys with flat signatures, since these and the sharp modulations are not both wanted at the same time, six of the notes can be instantaneously changed for the purpose, at any time, in a manner hereafter explained.

The whole of the keys are well under the hand, and, if the performer knows which note he ought to use, he can take it in any usual chord without difficulty.

Fig. 1 represents one octave of the keyboard as arranged for the key of C, with provision for modulating into keys with sharps.

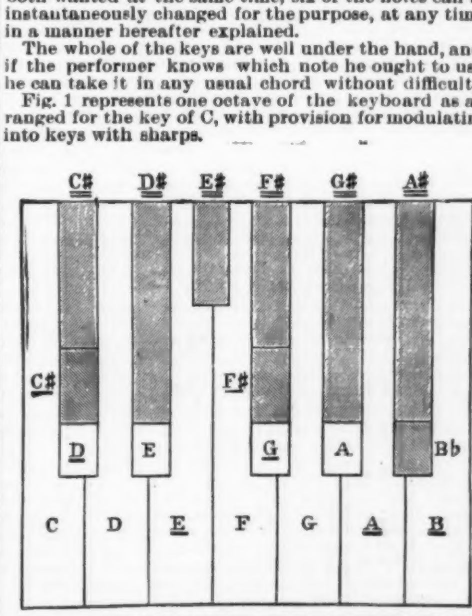
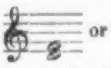


FIG. 1.—AS ARRANGED FOR MODULATION INTO KEYS WITH SHARPS.

In order to explain the exact intonation or musical position of the notes, the author adopts a notation already pretty well known, namely, when the letter indicating a note has no line above or below it, it is intended to correspond with what may be called the "Pythagorean" position of that note, which is given by a succession of fifths upward from C as a base. If the letter has a stroke below it—thus, E—it is a comma below that position; and if the stroke is above—

thus, E♭—it is a comma above that position. Two strokes below—thus, C♯—indicate two commas below.

Now, in the first place it will be seen that the ordinary seven white keys indicate the seven ordinary notes of the major scale of C, according to the intonation usually understood, *i. e.*, the major triads on the tonic, dominant, and subdominant, being perfectly in tune.

But as, for certain harmonies, variations of some of these notes are required, there are four alternative small white notes, D, E, G, and A, placed at the near the note D is the one required to make the true extremity of four of the black ones. For example, minor third  or the true fifth 

The position of the keys for the sharp notes, and also their intonations, will be seen in the figure. F♯ and C♯ each require alternative values, a comma distant from each other, and these are obtained by dividing the black keys in the manner formerly practiced with some organs in this country.

It will be seen that there are in all twenty effective finger keys, each sounding a separate note.

When it is requisite to modulate into keys with flats, the above arrangement will not answer; and the necessary change is made by a lever placed conveniently for being worked by the knee of the player, like the swell of a harmonium.

When this is pushed over, the six hindmost black keys are altered from sharps to flats, as shown in Fig. 2. C♯ and F♯ still remain, and an alternative B♭ and an alternative F are added. This change gives six new notes, so that the total number of sounds used in the octave, for the key of C with its modulations, is twenty-six.

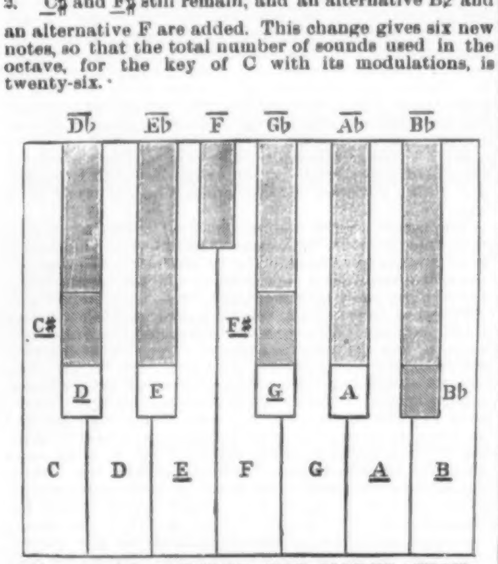


FIG. 2.—AS ALTERED FOR MODULATION INTO KEYS WITH FLATS.

As a further indication of the exact musical positions of these twenty-six notes, their ratios of vibration with the keynote C may also be given. And the logarithms of these (here limited, for simplicity, to three places) will represent approximately the height of each note above C. In this scale an octave is represented by 301, a mean semitone by 25, and a comma by 5.

Table of the Positions of the various Notes used for the Key of C.

Note	Ratio.	Logarithm.	Note	Ratio.	Logarithm.
C	1	0			
D	$\frac{9}{8}$	51	$\underline{D}$	$\frac{10}{9}$	46
$\underline{E}$	$\frac{5}{4}$	97	E	$\frac{81}{64}$	102
F	$\frac{4}{3}$	125	$\bar{F}$	$\frac{27}{20}$	130
G	$\frac{3}{2}$	176	$\underline{G}$	$\frac{40}{27}$	171
A	$\frac{5}{3}$	222	A	$\frac{27}{16}$	227
B	$\frac{15}{8}$	273			
F♯	$\frac{45}{32}$	148	F♯	$\frac{25}{18}$	143
C♯	$\frac{135}{128}$	23	C♯	$\frac{25}{24}$	18
G♯	$\frac{25}{16}$	194			
D♯	$\frac{75}{64}$	69			
A♯	$\frac{225}{128}$	245			
E♯	$\frac{675}{512}$	120			
B♭	$\frac{9}{5}$	255	B♭	$\frac{16}{9}$	250
$\bar{E}$♭	$\frac{6}{5}$	79			
$\bar{A}$♭	$\frac{8}{5}$	204			
$\bar{D}$♭	$\frac{16}{15}$	28			
G♭	$\frac{64}{45}$	153			

This information will enable any student of musical theory to judge of the capability of the instrument to play modern music with just intonation. The great object is, of course, to play the consonant triads, major and minor, in strict tune, and it will be found that the instrument, as above arranged, will play the following

Major Triads on—
C, D, E, F, G, A, B,
F♯, B♭, E♭, A♭, D♭, G♭,

Minor Triads on—
C, D, E, F, G, A, B,
F♯, C♯, G♯, D♯, A♯, B♭,

and some of each in duplicate with a comma variation. These would certainly seem sufficient for all ordinary music in C major or A minor.

By means of the transposing movement, the keyboard can be set upon either of the eleven other keys, for which a similar modulating power is obtained, except in some very remote cases. In order, however, to effect this, ten additional notes are used, making thirty-six in all. But the adaptation of them is entirely automatic, and the mechanism for this purpose constitutes one of the chief novelties of the invention.

This is the provision for the purpose by the manufacturer. Now let us see what the *performer* has to do.

In the first place, whatever key the original composition is in, it must be played in the key of C. In these days of strict examination by the College of Organists, it is not uncommon to find players who can transpose at first sight from any key into any other. For players who cannot do this the piece will have to be recopied, but this is nothing in comparison with the great gain in simplicity of the keyboard.

Secondly, the performer has not only to play the music in the ordinary way, but he has another problem before him—namely, where certain notes are in duplicate, he has to decide which of the two to use. Now this, although by no means a difficult matter, requires some knowledge of the theory of music, in a sense beyond what is ordinarily taught. To explain it would lead us into more technical detail than would be proper here; but Dr. Tanaka, in compassion for those unfortunates with whom music "has not been made an affair of vibrations," has shown that the printed music can have certain very simple symbols prefixed to the notes, which will easily guide the purely "practical" player what to do.

In this way any competent organist, though he may never have heard of the system before, may, after a few minutes' explanation, and a quarter of an hour's practice, play any piece of music correctly in the true musical intonation, a result which I believe has never been attained by any former instrument, and which says much for the ingenuity of the whole contrivance.

It is recorded that the Emperor of Germany expressed a wish to see the experiment tried on a large organ, and the inventor is now engaged in constructing one with eight stops, and a simplified enharmonic pedal clavier, for the Prussian government.

WILLIAM POLE.

[Continued from SUPPLEMENT, No. 823, page 13150.]

THEORY AND PRACTICE IN METALLURGY.*

By Professor W. C. ROBERTS-AUSTEN, C.B., F.R.S., President of the Section.

ADVANCES IN METALLURGIC PRACTICE.

(3) THE foregoing instances have been given to indicate the general nature of metallurgical chemistry. It will be well now to show how the great advances in metallurgical practice have been made in the past, with a view to ascertain what principles should guide us in the future.

It is a grave mistake to suppose that in industry, any more than in art, national advance takes place always under the guidance of a master possessed of some new gift of invention; yet we have been reminded that we are apt to be reverent to these alone, as if the nation had been unprogressive, and suddenly awakened by the genius of one man. The way for any great technical advance is prepared by the patient acquisition of facts by investigators of pure science. Whether the investigators are few or many, and, consequently, whether progress is slow or rapid, will depend in no small measure on the spirit of the nation as a whole. A genius whose practical order of mind enables him to make some great invention suddenly arises, apparently by chance, but his coming will, in most cases, be found to have "followed hard upon" the discovery by some scientific worker of an important fact, or even the accurate determination of a set of physical constants. No elaborate monograph need have reached the practical man—a newspaper paragraph or a lecture at a mechanic's institute may have been sufficient to give him the necessary impulse; but the possessors of minds which are essentially practical often forget how valuable to them have been the fragments of knowledge they have so insensibly acquired that they are almost unconscious of having received any external aid.

The investigating and the industrial faculty are sometimes, though rarely, united in one individual. Rapid advance is often made by those who are untrammeled by a burden of precedent, but it should be remembered that though the few successes which have been attained in the course of ignorant practice may come into prominence, none of the countless failures are seen.

I would briefly direct attention to certain processes which have been adopted since the year 1849, when Dr. Percy presided over this section at Birmingham, a great metallurgical center. In that year the president of the association made a reference to metallurgy, a very brief one, for Dr. Robinson only said, "The manufacture of iron has been augmented sixfold by the use of the puddling furnace and the hot blast, both gifts of theory." And so, it may be added, are most of the important processes which have since been devised. Take the greatest metallurgical advance of all, the Bessemer process, which has probably done more than any other to promote the material advance of all countries. It was first communicated to the world at the Cheltenham meeting of the British Association, 1856. Its nature is well known, and I need only say that it depends on the fact that when air is blown through a bath of impure molten iron, sufficient heat is evolved by the rapid combustion of silicon, manganese, and carbon, to maintain the bath fluid after these elements have been eliminated, there being no external source of heat, as there is in the puddling furnace or the refinery hearth. We have recently been told that at an early and perilous stage of the Bessemer process confidence in the experiments was restored by the observation that the temperature of the "blown" metal contained in a crucible was higher than that of the furnace in which it was placed. The historian of the future will not fail to record that the way for the Bessemer process had been prepared by the theoretical work of Andrews, 1848, and of Favre and Silbermann, 1852, whose work on the calorific power of various elements showed that silicon and phosphorus might be utilized as fuel, because great heat is engendered by their combustion.

The basic process for removing phosphorus, a process of great national importance, the development of which we owe to Thomas and Gilchrist, is entirely the outcome of purely theoretical teaching, in connection with which the names of Grüner and Percy deserve special mention. In the other great group of processes for the production of steel, those in which Siemens' regenerative furnace is employed, we have the direct influence of a highly trained theorist, who concluded his address as president of this association in 1882 by reminding us that "in the great workshop of nature there is no line of demarkation to be drawn between the most exalted speculation and commonplace practice." The recent introduction of the method of heating by radiation is, of course, the result of purely theoretical considerations.

The progress in the methods of extracting the precious metals has been very great, both on the chemical and engineering sides, but it is curious that in the metallurgy of gold and silver, many ancient processes survive which were arrived at empirically—a noteworthy exception being presented by the chlorine process for refining gold, by the aid of which many millions sterling of gold have been purified. The late Mr. H. B. Miller based this process for separating silver from gold on the knowledge of the fact that chloride of gold cannot exist at a bright red heat. The tension of dissociation of chloride of gold is high, but the precious metal is not carried forward by the gaseous stream, at least not while chloride of silver is being formed.

The influence of scientific investigation is, however, more evident in that portion of the metallurgic art which deals with the adaptation of metals for use, rather than with their actual extraction from the ores.

Only sixteen years ago Sir Nathaniel Barnaby, then director of naval construction, wrote, "Our distrust of steel is so great that the material may be said to be altogether unused by private ship builders, . . . and marine engineers appear to be equally afraid of it." He adds, "The question we have to put to the steel makers is, what are our prospects of obtaining a material which we can use without such delicate manipulation and so much fear and trembling?" All this is changed, for, as Mr. Elgar informs me, in the year ending on June 30 last, no less than 401 ships, of three-quarters of a million gross tonnage, were being built of steel in the United Kingdom.

Why is it, then, that steel has become the material on which we rely for our ships and for our national defense, and of which such a splendid structure as the Forth Bridge is constructed? It is because side by side with great improvement in the quality of certain varieties of steel, which is the result of using the open-hearth process, elaborate researches have shown what is the most suitable mechanical and thermal treatment for the metal; but the adaptation of steel for industrial use is only typical, as the interest in this branch of metallurgy generally appears for the moment to be centered in the question whether metals can, like many metalloids, pass under the application of heat or mechanical stress from a normal state to an allotropic one, or whether metals may even exist in numerous isomeric states.

It is impossible to deal historically with the subject now, further than by stating that the belief in more than one "modification" is old and widespread, and was expressed by Paracelsus, who thought that copper "contains in itself its female, which could be isolated so as to give two metals, . . . different in their fusion and malleability," as steel and iron differ. Within the last few years Schutzenberger has shown that two modifications of copper can exist, the normal one having a density of 8·95, while that of the allotropic modification is only 8, and is, moreover, rapidly attacked by dilute nitric acid, which is without action on ordinary copper. It may be added that Lord Rayleigh's plea for the investigation of the simpler chemical reactions has been partly met, in the case of copper, by the experiments conducted by V. H. Veley on the conditions of chemical change between nitric acid and certain metals.

Bergmann, 1781, actually calls iron polymorphous, and says that it plays the part of many metals. "Adeo ut jure dici queat polymorphum ferrum plurium simul metallorum vices sustinere." Osmond has recently demonstrated the fact that at least two modifications of iron must exist.

Professor Spring, of Liege, has given evidence that in cooling lead-tin alloys polymerization may take place after the alloys have become solid, and it seems to be admitted that the same cause underlies both polymerization and allotropy. The phenomenon of allotropy is dependent upon the number of the atoms in each molecule, but we are at present far from being able to say what degree of importance is to be attached to the relative distance between the atoms of a metal or to the "position of one and the same atom" in a metallic molecule, whether the metal be alloyed or free, and it must be admitted that in this respect organic chemistry is far in advance of metallurgic chemistry. I cannot, as yet, state what is the atomic grouping in the brilliantly colored gold-aluminum alloy, $AuAl_2$, which I have had the good fortune to discover, but in it the gold is probably present in the

* Address to the Chemical Section of the British Association, Cardiff, 1891.

same state as that in which it occurs in the purple of cassius.

Much valuable information on the important question of allotropy in metals has already been gathered by Pionchon, Ditte, Moissan, Le Chatelier, and Osmond, but reference can only be made to the work of the two latter. Le Chatelier concludes that in metals which do not undergo molecular transformation the electrical resistance increases proportionally to the temperature. The same law holds good for other metals at temperatures above that at which their last change takes place; for example, in the case of nickel above 340 deg., and in that of iron above 850 deg.

It is probable that minute quantities of foreign matter which profoundly modify the structure of masses of metal also induce allotropic changes. In the case of the remarkable action of impurities upon pure gold I have suggested that the modifications which are produced may have direct connection with the periodic law of Mendeleeff, and that the causes of the specific variations in the properties of iron and steel may thus be explained. The question is of great industrial importance, especially in the case of iron; and Osmond, whose excellent work I have already brought before the members of this association in a lecture delivered at Newcastle in 1889, has specially studied the influence upon iron exerted by certain elements. He shows that elements whose atomic volumes are smaller than that of iron delay, during the cooling of a mass of iron from a red heat, the change of the β or hard variety of iron to the α or soft variety. On the other hand, elements whose atomic volumes are greater than that of iron tend to hasten the change of β to α iron. It is, however, unnecessary to dwell upon this subject, as it was dealt with last year in the address of the president of the association.

It may be added that the recent use of nickel steel for armor plate, and the advocacy of the use of copper steel for certain purposes, is the industrial justification of my own views as to the influence of the atomic volume of an added element on the mechanical properties of iron, and it is remarkable that the two bodies, silicon and aluminum, the properties of which, when in a free state, are so totally different, should, nevertheless, when they are alloyed with iron, affect it in the same way. Silicon and aluminum have almost the same atomic volumes.

The consequences of allotropic changes, which result in alteration of structure, are very great. The case of the tin regimental buttons which fell into a shapeless heap when exposed to the rigorous winter at St. Petersburg is well known. The recent remarkable discovery by Hopkinson of the changes in the density of nickel steel (containing 22 per cent. of nickel) which are produced by cooling to — 30 deg. affords another instance. This variety of steel, after being frozen, is readily magnetizable, although it was not so before; its density, moreover, is permanently reduced by no less than 2 per cent. by the exposure to cold, and it is startling to contemplate the effect which would be produced by a visit to the arctic regions of a ship of war built in a temperate climate of ordinary steel, and clad with some three thousand tons of such nickel steel armor; the shearing which would result from the expansion of the armor by exposure to cold would destroy the ship. Experimental compound armor plates have been made faced with 25 per cent. nickel steel, but it remains to be seen whether a similar though lessened effect would be produced on the steel containing 5 to 7 per cent. of nickel, specially studied by J. Riley, the use of which is warmly advocated for defensive purposes. Further information as to the molecular condition of nickel steel has within the last few weeks been given by Mercadier, who has shown that alloying iron with 25 per cent. of nickel renders the metal isotropic.

The molecular behavior of alloys is indeed most interesting. W. Spring has shown, in a long series of investigations, that alloys may be formed at the ordinary temperature, provided that minute particles of the constituent metals are submitted to great pressure. W. Hallock has recently given strong evidence in favor of the view that an alloy can be produced from its constituent metals with but slight pressure if the temperature to which the mass is submitted be above the melting point of the alloy, even though it be far below the melting point of the most easily fusible constituent. A further instance is thus afforded of the fact that a variation of either temperature or pressure will effect the union of solids.

It may be added that B. C. Damien is attempting to determine what variation in the melting point of alloys is produced by fusing them under a pressure of two hundred atmospheres. Italian physicists are also working on the compressibility of metals, and F. Boggio Lera has recently established the existence of an interesting relation between the coefficient cubic compressibility, the specific gravity, and the atomic weight of metals.

Few questions are more important than the measurement of very high temperatures. Within the last few years H. Le Chatelier has given us a thermo-couple of platinum with platinum containing 10 per cent. of rhodium, by the aid of which the problem of the measurement of high temperatures has been greatly simplified. A trustworthy pyrometer is now at hand for daily use in works, and the liberality of the Institution of Mechanical Engineers has enabled me to conduct an investigation which has resulted in the adoption of a simple appliance for obtaining, in the form of curves, photographic records of the cooling of masses of metal. A report on the subject has already been submitted to a committee, of which the director-general of ordnance factories is the chairman; and Dr. Anderson, to whom I am indebted for valuable assistance and advice, intends to add this new method for obtaining autographic curves of pyrometric measurements to the numerous self-recording appliances used in the government factories which he controls. It has proved to be easy to ascertain by the aid of this pyrometer what thermal changes take place during the cooling of molten masses of alloys, and it is possible to compare the rate of cooling of a white hot steel ingot at definite positions situated respectively near its surface and at its center, and thus to solve a problem which has hitherto been considered to be beyond the range of ordinary experimental methods. Some of the curves already obtained are of much interest, and will be submitted to the section. It is probable that the form of the curve which represents the solidification and cooling of a mass of molten metal affords an exceedingly delicate indication as to its purity.

Prof. H. E. Armstrong holds that the molecules of a metal can unite to form complexes with powers of coherence which vary with the presence of impurity. Crookes by a recent beautiful investigation has taught us how electrical evaporation of solid metals may be set up *in vacuo*, and has shown that even an alloy may be decomposed by such means. We may hope that such work will enable us to understand the principles on which the strength of materials depends.

Before leaving the consideration of questions connected with the molecular constitution of metals, I would specially refer to the excellent work of Heycock and Neville, who have extended to certain metals with low melting-points Raoult's investigations on the effect of impurity on the lowering of the freezing-point of solids. With the aid of one of my own students, H. C. Jenkins, I have further extended the experiments by studying the effect of impurity on the freezing-point of gold. Ramsay, by adopting Raoult's vapor-pressure method, has been led to the conclusion that when in solution in mercury the atom of a metal is, as a rule, identical with its molecule. The important research on the liquation of alloys has been extended by E. Matthey to the platinum-gold and palladium-gold series, in which the manipulation presented many difficulties; and E. J. Ball has studied the cases presented by the antimony-copper-lead series. Dr. Alder Wright has continued his own important investigation upon ternary alloys, and A. P. Laurie has worked on the electromotive force of the copper-zinc and copper-tin and gold-tin series, a field of research which promises fruitful results.

In no direction is advance more marked than in the mechanical testing of metals, in which branch of investigation this country, guided by Kirkaldy, undoubtedly took the leading part, and in connection with which Kennedy and Unwin have established world-wide reputations. I would also specially mention the work which has been carried on at the government testing works at Berlin under Dr. Wedding, and the elaborate investigations conducted at the Watertown Arsenal, Massachusetts, not to mention the numerous Continental testing laboratories directed by such men as Bauschinger, Jenny, and Tetmajer. Perhaps the most important recent work is that described by Prof. Martens, of Berlin, on the influence of heat on the strength of iron.

I might have dwelt at length on all these matters without doing half the service to metallurgy that I hope to render by earnestly pleading for the more extended teaching of the subject throughout the country, and for better laboratories, arranged on the model of engineering laboratories, in which the teaching is conducted with the aid of complete though small "plant." The Science and Art Department has done great and lasting service by directing that metallurgy shall be taught practically, but much remains to be done. With regard to laboratories in works, which are too often mere sheds, placed, say, behind the boiler house, when may we hope to rival the German chemical firm which has recently spent £19,000 upon its laboratories, in which research will be vigorously conducted? There is hardly any branch of inorganic chemistry which the metallurgist can afford to neglect, while many branches both of physics and mechanics are of utmost importance to him.

The wide range of study upon which a metallurgical student is rightly expected to enter is leading, it is to be feared, to diminution in the time devoted to analytical chemistry, and this most serious question should be pressed upon the attention of all who are responsible for the training of our future chemists. There can be no question that sufficient importance is not attached to the estimation of "traces," an analysis being considered to be satisfactory if the constituents found add up to 99·9, although a knowledge as to what elements represent the missing 0·1 may be more useful in affording an explanation of the defects in a material than all the rest of the analysis. This matter is of growing interest to practical men, and may explain their marked preference for chemists who have been trained in works, to those who have been educated in a college laboratory.

The necessity for affording public instruction in mining and metallurgy, with a view to the full development of the mineral wealth of a nation, is well known. The issues at stake are so vast that in this country it was considered advisable to provide a center of instruction in which the teaching of mining and metallurgy should not be left to private enterprise, or even entrusted to a corporation, but should be under the direct control of the government. With this end in view the Royal School of Mines was founded in 1851, and has supplied a body of well-trained men who have done excellent service for the country and her colonies. The government has recently taken a step in advance, and has further recognized the national importance of the teaching of mining and metallurgy by directing that the School of Mines shall be incorporated with the Royal College of Science, which is, I believe, destined to lead the scientific education of the nation.

It is to be feared, if the present prices of metals should be maintained, that as regards metalliferous mining, other than that of iron ores, our country has seen its best days, but the extraordinary mineral wealth of our colonies has recently been admirably described by my colleague, Prof. Le Neve Foster, in the inaugural lecture he delivered early in the present year, on his appointment to the chair so long held by Sir Warington Smyth (*Engineering*, vol. li., p. 200 *et seq.*). We shall, however, be able to rightly estimate the value of our birthright when the Imperial Institute is opened next year, and the nation will have reason to be grateful to Sir Frederic Abel for the care he is devoting to the development of this great institution, which will become the visible exponent of the splendors of our Indian and colonial resources, as well as a center of information.

The rapid growth of technical literature renders it unnecessary for a president of a section to devote his address to recording the progress of the subject he represents. As regards the most important part of our national metallurgy, this has, moreover, been admirably done by successive presidents of the Iron and Steel Institute, but it may have been expected that references would have been made to the main processes which have been adopted since Percy occupied this chair in 1849. I have not done so, because an enumeration of the processes would have been wholly inadequate, and a description of them impossible in the time at my disposal. Nevertheless it may be well to remind the section of a few of the more prominent additions the art has received in the last half century, and to offer a few statements to show the magnitude on which operations are conducted. As regards iron, in the last twenty-five years the price of steel has been reduced from £55 per ton to £5 per ton, but, after giving the world the inestimable boon of cheap steel by the labors of Bessemer and of Siemens, we were somewhat slow to accept the teaching of experiment as to the best method of treating the new material; on the other hand, Hadfield has brought manganese steel and aluminum steel within the reach of the manufacturer, and J. Riley has done much to develop the use of nickel steel.

In the case of copper, we have mainly contributed to extraordinary development of wet processes for its extraction from poor sulphides, and have met the great demands for pure metal by the wide adoption of electrolytic processes.

As regards the precious metals this country is well to the front, for Great Britain and her colonies produce about 38 per cent. of the gold supply of the world; and it may be well to add, as an indication of the scale on which operations are conducted, that in London alone 1 ton of gold and 5 tons of silver bullion can easily be refined in a day. No pains have been spared in perfecting the method of assay by which the value of gold and silver is ascertained, and during my twenty years' connection with the Royal Mint I have been responsible for the accuracy of the standard fineness of no less than 555 tons of gold coin, of an aggregate value of £70,500,000 sterling. In the case of the platinum industry, we owe its extraordinary development to the skill and enterprise of successive members of the firm of Johnson, Matthey & Co., who in later years have based their operations upon the results of the investigations of Deville and Debray. Some indication of the value of the material dealt with may be gathered from the statement that 2½ cwts. of platinum may easily be melted in a single charge, and that the firm, in one operation, extracted a mass of palladium valued at £30,000 from gold-platinum ore actually worth more than a million sterling.

I wish it were possible to record the services of those who have advanced metallurgy in connection with this Association, but the limitations of time render it difficult to do more than refer to some honored names of past presidents of this section. Michael Faraday, president of this section in 1837 and 1846, prepared the first specimen of nickel-steel, an alloy which seems to have so promising a future, but we may hardly claim him as a metallurgist; nor should I be justified in referring, in connection with metallurgical research, to my own master, Graham, president of this section in 1839, and again in 1844, were it not that his experiments on the occlusion of gases by metals have proved to be of such extraordinary practical importance in connection with the metallurgy of iron. Sir Lyon Playfair presided over this section in 1855, and again in 1859. His work in connection with Bunsen, on the composition of blast-furnace gases, was published in the Report of this Association in 1847, and formed the earliest of a group of researches, among which those of Sir Lowthian Bell proved to be of so much importance. The latter was president of this section in 1889. Sir F. Abel, president of this section in 1877, rendered enduring service to the government by his elaborate metallurgical investigations, in connection with materials used for guns and projectiles, as well as for defensive purposes. I will conclude this section of the address by a tribute to the memory of Percy. He may be said to have created the English literature of metallurgy, to have enriched it with the records of his own observations, and to have revived the love of our countrymen for metallurgical investigation. His valuable collection of specimens, made while professor at the Royal School of Mines, is now appropriately lodged at South Kensington, and will form a lasting memorial of his labors as a teacher. He exerted very noteworthy influence in guiding the public to a just appreciation of the labors of scientific men, and he lived to see an entire change in the tone of the public press in this respect. In the year of Percy's presidency over this section the *Times* gave only one-tenth of a column to a summary of the results of the last day but one of the meeting, although the usual discourse delivered on the previous evening had been devoted to a question of great importance, "The Application of Iron to Railway Purposes." Space was, however, found for the interesting statement that the "number of Quakeresses who attended the meetings of the sections was not a little remarkable." Compare the slender record of the *Times* of 1849 with its careful chronicle of the proceedings at any recent meeting of the Association.

In drawing this address to a close, I would point to the great importance of extending the use of the less known metals. Attention is at present concentrated on the production of aluminum, and reference has already been made to the Cowles process, in which, as in that of Heroult, the reduction of alumina is effected by carbon, at the very high temperature of the electric arc; while, on the other hand, in the Kleiner and similar processes, the electric current acts less as a source of heat than by decomposing a fluid bath, the aluminum being isolated by electrolytic action; and doubtless, in the immediate future, there will be a rapid increase in the number of metallurgical processes that depend on reactions which are set up by submitting chemical systems to electric stress. Incidental reference should be made to the growing importance of sodium, not only in cheapening the production of aluminum, but as a powerful weapon of research. In 1849, when Percy was president of this section, magnesium was a curiosity; now its production constitutes a considerable industry. We may confidently expect to see barium and calcium produced on a large scale as soon as their utility has been demonstrated by research. Minerals containing molybdenum are not rare; and the metal could probably be produced as cheaply as tin if a use were to be found for it. The quantities of vanadium and thallium which are available are also far from inconsiderable; but we, as yet, know little of the action of any of these metals when alloyed with others which are in daily use. The field

for investigation is vast indeed, for it must be remembered that valuable qualities may be conferred on a mass of metal by a very small quantity of another element. The useful quantities imparted to platinum by iridium are well known. A small quantity of tellurium obliterates the crystalline structure of bismuth; but we have lost an ancient art, which enabled brittle antimony to be cast into useful vessels. Two-tenths per cent. of zirconium increases the strength of gold enormously, while the same amount of bismuth reduces the tenacity to a very low point. Chromium, cobalt, tungsten, titanium, cadmium, zirconium, and lithium are already well known in the arts, and the valuable properties which metallic chromium and tungsten confer upon steel are beginning to be generally recognized, as the last exhibition at Paris abundantly showed; but as isolated metals, we know but little of them. Is the development of the rarer metals to be left to other countries? Means for the prosecution of research are forthcoming, and a rich reward awaits the labors of the chemists who could bring themselves to divert their attention, for even a brief period, from the investigation of organic compounds, in order to raise alloys from the obscurity in which they are at present left.

It must not be forgotten that metallurgical enterprise rests on (1) scientific knowledge, (2) capital, and (3) labor, and that if the results of industrial operations are to prove remunerative, much must depend on the relation of these three elements, though it is difficult to determine accurately their relative importance. A modern ironworks may have an army of ten thousand workmen, and commercial success or failure will depend in no small measure on the method adopted in organizing the labor. The relations between capital and labor are of so much interest at the present time that I do not hesitate to offer a few words on the subject.

Many examples might be borrowed from metallurgical enterprises in this and other countries to show that their nature is often precarious, and that failure is easily induced by what appear to be comparatively slight causes. Capitalists might consequently tend to select government securities for investment in preference to metallurgical works, and the laboring population would then severely suffer. It is only reasonable, therefore, that if capitalists are exposed to great risks, they should, in the event of success, receive the greater part of the profits. There is a widespread feeling that the interests of capital and labor must be antagonistic, and as it is impossible to ignore the fact that the conflict between them is giving rise to grave apprehension, it becomes the duty of all who possess influence to strive not merely for peace, but to range themselves on the side of justice and humanity. The great labor question cannot be solved except by assuming as a principle that private ownership must be held inviolable, but it must be admitted that there was a time when capital had become arbitrary and some kind of united action on the part of workmen was needed in self-defense. If, however, we turn to the action of the leaders of trade unions in the recent lamentable strikes, we are presented with a picture which many of us can only view as that of tyranny of the most close and oppressive kind, in which individual freedom cannot even be recognized. There are hundreds of owners of works who long to devote themselves to the welfare of those they employ, but who can do little against the influence of the professional agitator, and are merely saddened by contact with prejudice and ignorance. I believe the view to be correct that some system by which the workman participates in the profits of enterprise will afford the most hope of putting an end to labor disputes, and we are told that profit sharing tends to destroy the workmen's sense of social exclusion from the capitalistic board, and contents him by elevating him from the precarious position of a hired laborer. No pains should therefore be spared in perfecting a system of profit sharing.

Pensions for long service are great aids to patience and fidelity, and very much may be hoped from the fact that strenuous efforts are being made by men really competent to lead. The report of the Labor Commission which is now sitting will be looked for with keen interest. Watchful care over the health, interests, and instruction of the employed is exercised by many owners of works; and in this respect the Dowlais works, which are being transplanted into your midst at Cardiff, have long presented a noteworthy example. Workmen must not forget that the choice of their own leaders is in their own hands, and on this the future mainly depends. "We may lay it down as a perpetual law that workmen's associations should be so organized and governed as to furnish the best and most suitable means for attaining what is aimed at, that is to say, for helping each individual member to better his condition to the utmost in body, mind, and property." The words will be found in the Encyclical letter which Pope Leo XIII. has recently issued on the "Condition of Labor." To me it is specially interesting that the Bishop of Rome in his forcible appeal again and again cites the opinion of St. Thomas Aquinas, who was a learned chemist as well as a theologian.

Those of us who realize that "the higher mysteries of being, if penetrable at all by human intellect, require other weapons than those of calculation and experiment," should be fully sensible of our individual responsibility. Seeing that the study of the relations between capital and labor involves the consideration of the complex problems of existence, the solution of which is at present hidden from us, we shall feel with Andrew Lang that "where, as a matter of science, we know nothing, we can only utter the message of our temperament." My own leads me to hope that the patriotism of the workmen will prevent them from driving our national industries from these shores, and I would ask those to whom the direction of the metallurgical works of this country is confided to remember that we have to deal both with metals and with men, and have reason to be grateful to all who extend the boundaries, not only of our knowledge, but also of our sympathy.

A LITTLE pulverized sal-ammoniac sprinkled on tin will make it flow free and clear. There is nothing but an alloy of other metal that will make it melt at less than its normal temperature.

ON THE ORIGIN, PROPAGATION, AND PREVENTION OF PHTHISIS.

By JOHN TYNDALL.

IT is now a little over nine years since I received here, at Hind Head, a memoir by Professor Koch on the "Etiology of Tuberculosis." Taking it in all its bearings, the memoir seemed to me of extraordinary interest and importance, not only to the medical men of England, but to the community at large. I, therefore, drew up and sent an account of it to the *Times*. The discovery of the tubercle bacillus was therein announced for the first time, and by experiments of the most definite and varied character the propagation and action of this terrible organism were demonstrated.

With regard to his recent labors, Professor Koch may or may not have been hasty in the publication of his remedies for consumption. On this point it would be out of place, on my part, to say a word. But the investigations which first rendered his name famous, and which, I believe, were introduced to the English public by myself, are irrefragable. His renowned inquiry on anthrax caused him to be transferred from a modest position, near Breslau, to the directorship of the Imperial Sanitary Institute of Berlin, where he was soon surrounded by able colleagues and assistants. Conspicuous among these was Dr. Georg Cornet, whose labors on the diffusion of tuberculosis constitute the subject of this article.

After the investigation of Koch, various questions of moment pushed themselves imperiously to the front: How is phthisis generated? How is it propagated? What is the part played by the air as the vehicle of tubercle bacilli? How are healthy lungs to be protected from their ravages? What value is to be assigned to the hypothesis of predisposition and hereditary transmission? Cornet describes the attempts made to answer these and other questions. The results were conflicting, and when subjected to critical examination they were proved, for the most part, inadequate and inconclusive. The art of experiment is different from that of observation; so much so, that good observers frequently prove but indifferent experimenters. It was his education as an experimenter that gave Pasteur such immense advantage over Pouchet in their celebrated controversy on "spontaneous generation"; and it is on the score of experiment that the writers examined by Cornet were found most wanting. One evil result of this conflict of opinion, as to the propagation and prevention of phthisis, was the unwarrantable indifference which is generated among medical men.

The researches referred to and criticised by Cornet are too voluminous to be mentioned in detail. Valuable information was, to some extent, yielded by these researches, but they nevertheless left the subject in a state of vagueness and uncertainty. Cornet, in fact, when he began his inquiry, found himself confronted by a practically untrodden domain. He entered it with a full knowledge of the gravity of his task. The result of his investigation is a memoir of 140 pages, the importance of which, and the vast amount of labor involved in it, can be appreciated by those only who have read it and studied it from beginning to end.

That the matter expectorated by phthisical patients is infectious had been placed by previous investigations beyond doubt. The principal question set before himself by Cornet had reference to the part played by the air in the propagation of lung disease: Is the breath of persons suffering from phthisis charged, as assumed by some, with bacilli? or is it, as assumed by others, free from the organism? The drawing of the air through media able to intercept its floating particles, and the examination of the media afterward, might, at first sight, appear the more simple way of answering this question. But to examine a thousand liters of air would require a considerable time, and this is only one-twelfth of the volume which a man breathing quietly expires every day. If the air were only sparingly charged with bacilli, the amount necessary for a thorough examination might prove overwhelming. Instead of the air, therefore, Cornet chose for examination the *precipitate* from the air; that is to say, the dust of the sick room, which must contain the bacilli in greater numbers than the air itself.

He chose for his field of operations seven distinct hospitals (Krankenhausern), three lunatic asylums (Irrenanstalten), fifty-three private houses, and various localities, including private asylums, lecture rooms, surgical wards, public buildings, and the open street. The smallness of the bacilli has given currency to erroneous notions regarding their power of floating in the air. The bacilli are not only bodies, but heavy bodies, which sink in water and pus, and much more rapidly in calm air. Cornet gathered his dust from places inaccessible to the sputum issuing directly from the coughing patient. He rubbed it off high-hung pictures, clock cases, the boards and rails at the back of the patient's bed, and also off the walls behind it. The enormous care necessary in such experiments, and, indeed, in the use of instruments generally, has not yet, I fear, been universally realized by medical men. With a care worthy of imitation, Cornet sterilized the instruments with which his dust was collected, and also the vessels in which it was placed.

The cultivation of the tubercle bacilli directly from the dust proved impracticable. Their extraordinary slowness of development enabled other organisms—weeds of the pathogenic garden—which were always present, to overpower and practically stifle them. Cornet, therefore, resorted to the infection of guinea pigs with his dust. If tuberculosis followed from such inoculation, a proof of virulence would be obtained which the microscope could never furnish. The dust, after being intimately mixed with a suitable liquid, was injected into the abdomen of the guinea pig. For every sample of dust, two, three, four, or more animals were employed. In numerous cases the infected animals died a day or two after inoculation. Such rapid deaths, however, were not due to the tubercle bacillus, which, as already stated, is extremely slow of development, but to organisms which set up peritonitis and other fatal disorders. Usually, however, some of the group of guinea pigs escaped this quick mortality, and, to permit of the development of the bacilli, they were allowed to live on thirty, forty, or fifty days. The survivors were then killed and examined. In some cases the animals were found charged with tubercle bacilli, the virulence of the inoculated matter being thus established. In other cases the organs of the guinea pigs were found healthy, thus proving the harmlessness of the dust.

It must here be borne in mind that the bacilli mixed with Cornet's dust must have first floated in the air, and been deposited by it. Considering the number of persons who suffer from phthisis, and the billions of bacilli expectorated by each of them, it would seem a fair *a priori* deduction that wherever people with their normal proportion of consumptive subjects aggregate, the tubercle bacillus must be present everywhere. Hence the doctrine of "ubiquity," enunciated and defended by many writers on this question. Common observation throws doubt upon the doctrine, while the experiments of Cornet are distinctly opposed to it. Tested by the dust deposited on their furniture or rubbed from their walls, the wards of some of the hospitals were found entirely free from bacilli, while others were found to be richly and fatally endowed with the organism. Cornet, it may be remarked, does not contend that his negative results possess demonstrative force. He is quite ready to admit that, where he failed to find them, bacilli may have escaped him. But he justly remarks that until we have discovered a bacterian magnet, capable of drawing every bacillus from its hiding place, experiment must remain more or less open to this criticism. Cornet's object is a practical one. He has to consider the *probability*, rather than the remote *possibility*, of infection. The possibility, even in places where no bacilli show themselves, may be admitted, while the probability is denied. Such places, Cornet contends, are practically free from danger.

In the differences as to the infectiousness here pointed out, we have an illustration of wisely applied knowledge, care, and control, as contrasted with negligence or ignorance, on the part of hospital authorities. And this may be a fitting place to refer to a most impressive example of what can be accomplished, by resolute supervision, on the part of hospital doctors and nurses. A glance at the state of things existing some years ago will enable us to realize more fully the ameliorations of to-day. I once had occasion to ask Professor Klebs, of Prague, for his opinion of the antiseptic system of surgery. He replied: "You in England are not in a position to appreciate the magnitude of the advance made by Lister. English surgeons were long ago led to recognize the connection between mortality and dirt, and they spared no pains in rendering their wards as clean as it was possible to make them. Wards thus purified showed a mortality almost as low as other wards in which the antiseptic system was employed. The condition of things in *our* hospitals is totally different; and it is only among us, on the Continent, that the vast amelioration introduced by Lister can be properly apprehended." I may say that Lister himself once described hospitals in his own country which, in regard to uncleanliness and consequent mortality, might have vied with those on the Continent. Klebs' letter was written many years ago. Later on the authorities of German hospitals bestirred themselves, with the splendid result disclosed by Cornet, that institutions which were formerly the chief breeding grounds of pathogenic organisms are now raised to a pitch of salubrity surpassing that of the open street.

Cornet thus grapples with the grave question which here occupies us. How, he asks, does the tubercle bacillus reach the lungs, and how is it transported thence into the air? Is it the sputum alone that carries the organism, or do the bacilli mingle with the breath? This is the problem of problems, the answer to which will show whether we are able to protect ourselves against tuberculosis, whether we can impose limits on the scourge, or whether, with hands tied, we have to surrender ourselves to its malignant sway. If the tubercle bacilli are carried outward by the breath, then nothing remains for us but to wait till an infected puff of expired air conveys to us our doom. A kind of fatalism, sometimes dominant in relation to this question, would have its justification. There is no inhabited place without its proportion of phthisical subjects, who, if the foregoing supposition were correct, would be condemned to infect their neighbors. Terrible in this case would be the doom of the sufferer, whom we should be enforced to avoid, as in earlier ages the plague-stricken were avoided. Terrible, moreover, to the invalid would be the consciousness that with every discharge from his lungs he was spreading death among those around him. "Such a state of things," says Cornet, "would soon loosen the bonds of the family and of society." Happily the facts of the case are very different from those here set forth.

"I would not," says our author, "go into this subject so fully, I would not here repeat what is already known, were I not convinced that, in regard to this special point, the most erroneous notions are prevalent, not only among the general public, but even among highly cultivated medical men. Misled by such notions, precautions are adopted which are simply calculated to defeat the end in view. Thus it is that while one physician anxiously guards against the expired breath of the phthisical patient, another is careful to have his spittoon so covered up that no bacilli can escape into the air by evaporation. Neither of them makes any inquiry about the really crucial point—whether the patient has deposited *all* his sputum in the spittoon, thus avoiding the possibility of the expectorated matter becoming dry, and reduced afterward to a powder capable of being inhaled.

"While a positive phthisiophobia appears to have taken possession of some minds, others ignore almost completely the possibility of infection. The fact that investigations have been published of late, with the object of discovering tubercle bacilli in the breath, sufficiently indicates that the conclusive researches of earlier investigators have not received the proper amount of attention.

"We must regard it," says Cornet, "as firmly established that, under no circumstance, can the bacteria contained in a liquid, or strewn upon a wet surface, escape by evaporation or be carried away by currents of air. By an irrefragable series of experiments Nageli has placed this beyond doubt."

The evidence that the sputum is the real source of tuberculous infection is conclusive; and here Cornet earnestly directs attention to the fact that in the houses of the poor the patient commonly spits upon the floor,

where the sputum dries and is rubbed into infectious dust by the feet of persons passing over it. The danger becomes greatest when the dry floor is swept by brush or broom. There is a still graver danger connected with the habits of well to-do people who occupy clean and salubrious houses. This is the common practice of spitting into pocket handkerchiefs. Here the sputum is soon dried by the warmth of the pocket, the subsequent use of the handkerchief causing it to be rubbed into virulent dust. This constitutes a danger of the highest consequence, both to the individual using the handkerchief and to persons in his immediate neighborhood.

It is a primary doctrine with both Koch and Cornet that tuberculosis arises from infection by the tubercle bacillus. Predisposition, or hereditary tendency, as a *cause* of phthisis, is rejected by both of them. Facts, however, are not wanting which suggest the notion of predisposition. Cornet once attended, in a hotel, an actress far advanced in phthisis. A guest, taking possession of her room after her death, or removal, might undoubtedly become infected. The antecedents of the room being unknown, the case of such a guest would, in all probability, be referred to predisposition. It might be declared, with perfect sincerity, that for years he had had no communication with phthisical persons. There is very little doubt that numbers of cases of tuberculosis, which have been referred to predisposition or inheritance, are to be really accounted for by infection in some such obscure way.

Cornet draws attention to hotels and lodging houses at, and on the way to, health resorts. He regards them as sources of danger, and he insists on the necessity of disinfecting the rooms and effects after the death or removal of tuberculous patients. He recommends physicians, before sending patients abroad, or to health resorts at home, to inform themselves, by strict inquiry, regarding the precautions taken to avoid infectious diseases, tuberculosis among the number. The attention of those responsible for the sanitary arrangements in the health resorts of England may be invited to the following observation of Cornet: "On a promenade, amid a hundred phthisical persons who are careful to expectorate into spittoons, the visitor is far safer than among a hundred men, taken at random, and embracing only the usual proportion of phthisical persons who spit upon the ground."

With regard to the *permanence* of the tubercle contagium, the following facts are illustrative. A woman, who had for two years suffered from a phthisical cough, and who had been in the habit of spitting first upon the ground, and afterward into a glass or a pocket handkerchief, was visited by Cornet. During her lifetime he proved the dust of her room to be infectious. Six weeks after her death he again visited the dwelling. Rubbing the dust from a square meter of the wall on which he had formerly found his infectious matter, and which had not been cleansed after the woman's death, he inoculated with it three of his guinea pigs. Examined forty days after the inoculation, two of the three were found tuberculous. Cornet reasons thus:

"No doubt the dust which had thus proved its virulence would have retained it for a longer time. Schill and Fischer, indeed, have proved that, after six months' preservation, dried sputum may retain its virulence. During this period, therefore, the possibility of infection by this dust is obviously open. When, moreover, the quantity of infectious matter inhaled is very small, a considerable time elapses before the development of the bacilli renders the malady distinct. Even if a year should elapse after the death of a phthisical patient before another member of the same household shows symptoms of lung disease, we are not entitled to assume a hereditary tendency without further proof. Aware of the facts above mentioned, we ought rather to ascribe the disease to infection by the dwelling, not to mention its possible derivation from other sources."

On January 14, 1888, Cornet visited a patient who, for three-quarters of a year, had suffered from tuberculosis of the lung and larynx. The dust of the room occupied by this man was proved to contain virulent infective matter. A brother of the patient, who, at the time of the examination of the dwelling, was alleged to be in perfect health, exhibited phthisis of the larynx four months afterward. "We are, surely," says Cornet, "warranted in ascribing this result, not to heredity, or any other hypothetical cause, but to the naked fact that the dust of this dwelling contained tubercle bacilli which were capable of infecting the lungs and larynx of a man, as they did the peritoneum of a guinea pig."

On December 31, 1887, Cornet visited a man who for two years had suffered from phthisis. He lived in the same room with two brothers who were very robust, one of whom, however, had begun to cough, though without any further evidence of serious disorder. The patient had been at home for eight days, while previously he had acted as foreman in a tailoring establishment. It was proved, to a certainty, that this patient had taken the place of a colleague who had died from phthisis of the throat, and who had been in the habit of expectorating copiously upon the floor. In the workroom, moreover, the present sufferer had occupied a place next to the man who died. Cornet called upon the proprietor of the establishment, who allowed him every opportunity of examining the room, in which eight or ten workmen were engaged. With dust rubbed from about two square meters of the wall, near the spot where the patient now works, Cornet infected guinea pigs and produced tuberculosis. He ridicules the notion of ascribing this man's malady to any hereditary endowment or predisposition, derived, say, from a phthisical mother, which, after sleeping for twenty years, woke up to action at the precise time when he was surrounded by infective matter. Our author regards this, and other similar cases which he adduces, as of special interest. The tuberculous virus was here found in rooms containing several workmen, who had thus an opportunity of infecting each other. The infection, moreover, occurred among tailors, who are known to be special sufferers from phthisis.

The general belief some time ago, which, to some extent, may hold its ground to the present hour, was that this wasting malady arose from some peculiarity in the individual constitution, independent of infection from without. Enormous mischief has been done through exaggerated and incorrect notions regarding the influence of predisposition and inheritance. Members of the same family were observed to fall victims to this scourge, but each was regarded as an independent source of the disease, to the exclusion of the thought that the one had infected the other. Two or three days ago an old man here at Hind Head told me that he had lost three children in succession through phthisis; and he mentioned another case where five or six robust brothers had fallen, successively, victims to the same disease. "I am sure," said the man, with a flash of intelligence across his usually unintelligent countenance, "*it must be catching.*"

Cornet describes some cases which irresistibly suggest family infection. In 1887 he visited a patient, the father of a family, who, six years previously, had lost by consumption a little girl fourteen years old. A year and a half afterward a daughter of the same man, twenty-one years old, fell a victim to the disease. One or two years later a robust son succumbed, while, a fortnight before Cornet's visit, a child a year and a half old had been carried away. Without doing violence to the evidence, as Cornet remarks, these cases may be justly regarded as due to family infection. For many years the father had suffered from a phthisical cough, and directly or indirectly he, in all probability, infected his children.

In connection with this subject, I may be permitted to relate a sad experience of my own. It is an easy excursion from my cottage in the Alps to the remarkable promontory called "The Nessel," on which stands a cluster of huts, occupied by peasants during the summer months. On visiting the Nessel three years ago, I was requested to look into a hut occupied by a man suffering from a racking cough, accompanied by copious expectoration. I did so. It was easy to see that the poor fellow was the victim of advanced lung disease. In the same hut lived his daughter, who, when I first saw her, presented the appearance of blooming health and vigor. Acquainted as I was with Koch's discoveries, I remarked to a friend who accompanied me that the girl lived in the midst of peril. We had here the precise conditions notified by Cornet. Spitting on the floor, drying of the sputum, and the subsequent treading of the infectious matter into dust. Whenever the hut was swept, this dust mingled freely with the air, and was of course inhaled.

I warned the girl against the danger to which she was exposed. But it is sometimes difficult to make even cultivated people comprehend the magnitude of this danger, or take the necessary precautions. A year afterward I visited the same hut. The father was standing in the midst of the room—a well-built man, nearly six feet high, and as straight as an arrow. He was wheezing heavily, being at intervals bowed down by the violence of his cough. On a stool in the same room sat his daughter, who, a year previously, had presented such a picture of Alpine strength and beauty. Her appearance shocked me. The light had gone out of her eyes, while the pallor of her face and her panting breath showed only too plainly that she also had been grasped by the destroyer. There are thousands at this moment in England in the position which I then occupied—standing helpless in the presence of a calamity that might have been avoided. All that could be done was to send the sufferers wine and such little delicacies as I could command. Last summer I learned that both father and daughter were dead, the daughter having been the first to succumb.

In opposition to those who consider that they have found bacilli in the breath of phthisical patients, Cornet adduces a number of very definite results. Patients have been caused to breathe against plates of glass coated with glycerine, which would undoubtedly have held the bacilli fast. Water has been examined, through which the air expired by phthisical lungs had been caused to pass. In this case the bacilli, being moist, would have been infallibly intercepted by the water. The aqueous vapor exhaled by consumptive lungs has been carefully condensed by ice; but no bacilli has, in any of these cases, been detected. It behooves those who have arrived at an opposite result to repeat their experiments with the most scrupulous care, so that no doubt should be suffered to rest upon a point of such supreme importance. The lungs, air passages, throat, and mouth all present wet surfaces, and it has been proved that even with sputum rich in bacilli, over which a current of air of considerable force had been driven, the air was found perfectly free from the organism.

The immunity as regards infection which to so great an extent is observed, is ascribed by Cornet in part to the intensely viscous character of the sputum when wet. Even after it has been subjected to a drying process its complete desiccation is opposed by its hygroscopic character. Cornet calls other investigators to bear him witness that the task of reducing well dried sputum to a fine powder, even in a mortar, is by no means an easy one. It is difficult to produce, in this way, a dust fine enough to remain suspended in the air. It would be an error to suppose that dry tuberculous phlegm, when trodden upon in the streets, sends a cloud of infected dust upward. Its hygroscopic qualities in great part prevent this. When dried sputum is reduced to powder in a humid place, it attracts to itself moisture, and collects into little balls. The streets in which phthisical persons expectorate are rendered innocuous by rain or by the artificial watering common in towns. Cornet regards this watering as an enormous sanitary advantage. No doubt when dry east winds prevail for a sufficient time, infectious dust will mingle with the air. During the easterly winds infectious diseases are known to be particularly prevalent. Our sufferings from influenza during the present year have been connected in my mind with the long continued easterly and northeasterly winds, which, sweeping over vast areas of dry land, brought with them the contagion that produced the malady. Besides the difficulty encountered before the sputum reaches the state of very fine powder, other difficulties are presented by the numberless angles and obstacles of the respiratory tract, and by the integrity of the ciliary epithelium, to the more or less vigorous action of which is due the fact that amid thousands of opportunities we have only here and there a case of infection.

The action of the tubercle bacillus is determined by the state of the surface with which it comes into contact. Wounds or lesions, caused by previous diseases, such as measles, whooping cough, and scarlatina, may exist along the respiratory canal. By illness, moreover, the epithelium may be impaired, the inhaled bacilli being thus offered a convenient domicile. If it be thought desirable to call such a state of things "predisposition," Cornet will raise no objection. Wherever a wounded or decaying tissue exists, the bacillus will find, unopposed, sufficient nutriment to enable it to increase in number, and to augment in vigor, before it comes into contact, and conflict, with the living cells underneath. It is not any such predisposition, but predisposition by inheritance as a *source* of phthisis that is contended against by Cornet. That Koch entertained a different opinion is declared to be absolutely erroneous. The admission that a disease may be favored, or promoted, by this or that circumstance is not tantamount to the assertion that in all, or nearly all, cases this circumstance is the cause, concomitant, or necessary precursor of the disease. This is the view generally entertained regarding "predisposition."

Cornet's further reasoning on this subject reveals his views so clearly that I will endeavor, in substance, to reproduce it here. Let a box be imagined filled with finely divided bacillus dust, and let a certain number of guinea pigs be caused, for a very short time, to inhale this dust. A few of them will be infected, while the great majority will escape. If the inhalation be prolonged, the number of animals infected will increase, until at length only one or two remain. With an exposure still more prolonged the surviving ones would undoubtedly succumb. Why then, in the first instance, does one animal contract tuberculosis and another not? Have they not all inhaled the same air, under the same connitions? Are the animals that have escaped the first contagion less "disposed" than the survivors to the disease? Assuming the animals to be all perfectly healthy, such differences will be observed. But, supposing them to be weakened in different degrees by previous disorders, the differences revealed in the case of healthy animals would be more pronounced. This, with human beings, is the normal state of things.

Take the case of a veteran who has been to the front in fifty different battles, who, right and left of him, has seen his comrades fall, until haply he remains the sole survivor of his regiment, without scratch or contusion. Shall we call him bullet proof? Will his safety be ascribed to an absence of "predisposition" to attract the bullets—thus enjoying an immunity which the superstition of former ages would have ascribed to him? Is he more bullet proof or less vulnerable than the comrade who by the first volley in the first battle was shot down? "How often," says Cornet, "do such cases repeat themselves in life? and are we able to do more than describe them as accidents? Unscientific as this word may appear, it is more in harmony with the truth than any artificial hypothesis."

The opportunities for incorrect reasoning in regard to phthisis are manifold. It is observed, for example, that a hospital attendant, who has had for years, even for decades, consumptive patients in his charge, has, nevertheless, escaped infection. The popular conclusion finds vent in the words, "It cannot be so dangerous after all!" Here, however, attention is fixed on a single fortunate individual, while the hundreds who, during the same time, have succumbed are forgotten. The danger of infection in different hospitals is a variable danger. In some we find bacilli, while in others we do not find them. It is no wonder, then, that among attendants who are thus exposed to different degrees of danger, some should be infected and others not. When in cases of diphtheria, typhus, cholera, smallpox, which are undeniably infectious diseases, an attendant escapes infection, we do not exclaim, "They are not so dangerous after all!" But this is the favorite expression when pulmonary consumption is in question. "When," adds Cornet, with a dash of indignation, "we observe the enormous increase of phthisis among the natives of Mentone, and find this ascribed to the abandonment of land labor, instead of to intercommunication with the consumptive patients who spend their winter at that health resort, it would seem as if some people shut their eyes willfully against the truth."

Again and again our author insists on the necessity of the most searching oversight on the part of physicians who have consumptive patients in charge. "I cannot," he says, "accept as valid the assertion that in well ordered hospitals provision is invariably made for expectoration into proper vessels, the conversion of the sputum into infectious dust being thereby rendered impossible. Take a case in point. One of the physicians to whose kindness I owe the possibility of carrying on my investigation assured me in the most positive manner that the patients in his hospital invariably used spittoons. A few minutes after this assurance had been given, and under the eyes of the director himself, I drew from the bed of a patient a pocket handkerchief filled with half-dried phlegm. I rubbed from the wall of the room, at a distance of half a meter from the bed of this patient, a quantity of dust with which, as I predicted, tuberculosis was produced. If, therefore, physicians, attendants, and patients do not work in unison, if the patient and his attendants be not accurately instructed and strictly controlled, the presence of the spittoon will not diminish the danger."

In the dwellings of private patients the perils here glanced at were most impressively brought home to the inquirer. In fifteen out of twenty-one sick rooms, that is to say, in more than two-thirds of them, Cornet found in the dust of the walls and bed furniture virulent tubercle bacilli. He refers to his published tables to prove that in no ward or room where the organism was found did the patients confine themselves to expectoration into spittoons, but were in the habit of spitting either upon the floors or into pocket handkerchiefs. In no single case, on the other hand, where spitting on the floor or into pocket handkerchiefs was strictly and effectually prohibited, did he find himself able to produce tuberculosis from the collected dust.

A point of considerable importance, more specially dealt with by Cornet in a further investigation, has reference to the allegation that physicians who attend tuberculous patients do not show among themselves the frightful mortality from phthisis that might be expected. This is often adduced as proof of the comparative harmlessness of the tubercle bacillus. No investigation, however, has proved that the mortality among

physicians by phthisis does not far exceed the average. And even should this mortality show no great preponderance, it is to be borne in mind that the number of physicians who, thanks to their education, are able to discern the first approaches of the malady, and to master it in time, is by no means inconsiderable. In the health resorts of Germany, Italy, France and Africa, we find numbers of physicians who have been compelled, by their own condition, to establish their practice in such places.

The memorable paper of which I have here given a concentrated abstract concludes with a chapter on "Preventive Measures," which are assuredly worthy of grave attention on the part of governments, of hospital authorities, and of the public at large. The character of these measures may be, in great part, gathered from the foregoing pages. It is more than once enunciated in Cornet's memoir that the first and greatest danger to which the phthisical patient is exposed is *himself*. If he is careless in the disposal of his phlegm, if he suffers it to become dry and converted into dust, then, by the inhalation of a contagium derived from the diseased portions of his own lung, he may infect the healthy portions. "If, therefore," says Cornet, "the phthisical patient, to avoid the guilt of self-murder, is compelled to exercise the utmost caution, he is equally bound to do so for the sake of his family, his children, and his servants and attendants. He must bestow the most anxious care upon the disposal of his sputum. Within doors he must never, under any circumstances, spit upon the floor, or employ his pocket handkerchief to receive his phlegm, but always and everywhere must use a proper spittoon. If he is absolutely faithful in the carrying out of these precautions, he may accept the tranquilizing assurance that he will neither injure himself nor prove a source of peril to those around him.

Though mindful of the danger of interfering with social arrangements, Cornet follows out his preventive measures in considerable detail. Hand spittoons, with a cover, he recommends, not with the view of preventing evaporation, but because flies have been known to carry infection from open vessels. Without condemning the practice, he does not favor the disinfection of sputum by carbolic acid and other chemicals. He deprecates the use of sand or sawdust in spittoons. On æsthetic grounds, he would have the spittoons of those who can afford it made ornamental, but earthenware saucers, such as those placed under flower pots, are recommended for the use of the poor. The consumptive patient must take care that not only in his own house, but also in the offices and workshops where he may be engaged, he is supplied with a proper spittoon. In public buildings, as in private houses, the corridors and staircases ought to be well supplied with these necessaries. The ascent of the stairs often provokes coughing and expectoration, and the means of disposing of the phlegm ought to be at hand. The directors of factories, and the masters of workshops, as well as the workmen themselves, ought to make sure that, under no circumstances, shall spitting on the floor or into a pocket handkerchief be tolerated.

One final word is still to be spoken. If we are to fight this enemy with success, the public must make common cause with the physician. The fear of spreading panic among the community, and more particularly among hospital nurses, must be dismissed. Unless nurses, patients, and public realize with clear intelligence the dangers to which they are exposed, they will not resort to the measures necessary for their protection. Should the sources of infection be only partially removed, the marked diminution of a malady which now destroys more human beings than all other infective diseases taken together will, as pointed out by Cornet, be "our exceeding great reward."

Dr. Cornet's great investigation, of which some account is given above, is entitled, "The Diffusion of Tubercle Bacilli exterior to the Body." It was published in 1888. A shorter though not less important inquiry, on "The Mortality of the Nursing Orders," was published in 1889. These two memoirs will be found permanently embodied in the fifth and sixth volumes of the *Zeitschrift fur Hygiene*. From a former paragraph it will be seen that Cornet's attention had been directed to those who, more than others, come closely into contact with infectious diseases, and that he throws doubt upon the notion that neither physicians nor nurses suffer from this proximity. No definite and thorough inquiry had, however, been made into this grave question. In face of the vague and contradictory statements which issued from the authorities of different hospitals, the problem cried aloud for solution. For aid and data, under these circumstances, Cornet resorted to Herr von Gossler, the Prussian Minister of State, who, at that time, had medical matters under his control. From him he received the most hearty furtherance and encouragement. Dr. von Gossler has recently resigned his post in the Prussian Ministry, but his readiness to forward the momentous inquiry on which Cornet was engaged merits the grateful recognition of the public and the praise of scientific men.

The number of female nurses in Prussia, as shown by the statistics of the Royal Bureau of Berlin for 1885, was 11,048. Of these the Catholic Sisters of Mercy numbered 5,470, or 49·51 per cent.; Evangelical nurses, 2,496, or 22·59 per cent.; nurses belonging to other societies and associations, 352, or 3·19 per cent.; while of unclassified nurses there were 2,730, or 24·71 per cent. of the whole. The male attendants, at the same time, numbered 3,162. Of these, 383 were Brothers of Mercy, 205 were deacons, while of unclassified attendants there were 2,574.

The sifting of these numbers was a labor of anxious care to Dr. Cornet. It had already been remarked by Guttstadt that the commercial attractions of hospital service were insufficient, without the help of some ideal motive, to secure a permanent staff. This motive was found in devotion through a sense of religious duty to the service of the sick. The sifting of his material made it clear to Cornet that, to secure a safe basis of generalization, by causing it to embrace a sufficient number of years, he must confine himself solely to the nurses of the Catholic orders. The greater freedom enjoyed and practiced by Protestants, in changing their occupation, in entering the married state, or through other modes of free action, rendered them unsuitable for the purpose he had in view. Cornet's inquiry extended over a quarter of a century. The returns furnished by thirty-eight hospitals, served by Catholic sisters and brethren, and embracing a yearly average of 4,020 attendants, showed the number of deaths during the period mentioned to be 2,099. Of these, 1,320 were caused by tuberculosis. In the State, as a whole, the proportion of deaths from this malady to the total number of deaths is known to be very high, reaching from one-fifth to one-seventh of the whole. In the hospitals this proportion was enormously increased. It rose on the average to almost two-thirds, or close upon 63 per cent. of the total number of deaths. In nearly half the hospitals even this high proportion was surpassed, the deaths in these amounting to three-fourths of the whole. Scarcely any other occupation, however injurious to health, shows a mortality equal to that found in these hospitals.

The following statistics furnish a picture of the state of things prevalent during the five-and-twenty years referred to. A healthy girl of 17, devoting herself to hospital nursing, dies on the average 21½ years sooner than a girl of the same age moving among the general population. A hospital nurse of the age of 25 has the same expectation of life as a person of the age of 58 in the general community. The age of 33 years in the hospital is of the same value as the age of 62 in common life. The difference between life value in the hospital and life value in the State increases from the age of 17 to 24; nurses of this latter age dying 22 years sooner than girls of the same age in the outside population. The difference afterward becomes less. In the fifties it amounts to only six or seven years, while later on it vanishes altogether. The reason of this is that the older nurses are gradually withdrawn from the heavier duties of their position and the attendant danger of infection.

In these hospitals, deaths from typhus and other infectious disorders exhibit a frequency far beyond the normal, but the enormous total augmentation is mainly to be ascribed to the frequency of deaths from tuberculosis. The excess of mortality is to be referred to the vocation of nursing, and the chances of infection involved in it. Cornet examines other assumptions that might be made to account for the mortality, and gives cogent reasons for dismissing them all. The tranquil lives led by the nurses, the freedom from all anxiety in regard to subsistence, the moderation observed in food and drink, all tend to the preservation of health. They live in peace, free from the irregularities of outside life, and their contentment and circumstances generally are calculated rather to prolong their days than to shorten them.

Cornet is very warm in his recognition of the devotion of these Catholic nurses, two-thirds of whom are sacrificed in the service which they render to suffering humanity. And they are sacrificed for the most part in the blossom of their years, for it is the younger nurses, engaged in the work of sweeping and dusting, whose occupation charges the air they breathe with virulent bacilli. The statistics of their mortality Cornet regards as a monumental record of their lofty self-denial, their noble, beneficent, and modest fidelity to what they regard as the religious duty of their lives.

But, he asks, is it necessary that this sacrifice should continue? His answer is an emphatic negative, to establish which he again sums up the results which we have learnt from his first memoir: It is universally recognized that tuberculosis is caused by tubercle bacilli, which reach the lungs through the inhalation of air in which the bacilli are diffused. They come almost exclusively from the dried sputum of consumptive persons. The moist sputum, as also the expired breath of the consumptive patient, is for this mode of infection without danger. If we can prevent the drying of the expectorated matter, we prevent in the same degree the possibility of infection. It is not, however, sufficient to place a spittoon at the disposal of the patient. The strictest surveillance must be exercised by both physicians and attendants, to enforce the proper use of the spittoon and to prevent the reckless disposal of the infective phlegm. Spitting on the floor or into pocket handkerchiefs is the main source of peril. To this must be added the soiling of the bed clothes and the wiping of the patient's mouth. The handkerchiefs used for this purpose must be handled with care, and boiled without delay. Various other sources of danger, kissing among them, will occur to the physician. A phthisical mother, by kissing her healthy child, may seal its doom. Notices, impressing on the patients the danger of not attending to the precautions laid down in the hospital, ought to be posted up in every sick room, while all willful infringements of the rules ought to be sternly punished. Thus may the terrible mortality of hospital nurses be diminished if not abolished; the wards where they are occupied being rendered as salubrious as those surgical wards in which no bacilli could be found.

Reflecting on the two investigations which I have here endeavored to bring before the readers of *The Fortnightly Review*, the question, "What, under the circumstances, is the duty of the English public and the English government?" forces itself upon the attention. Will the former suffer themselves to be deluded, and the latter frightened, by a number of loud-tongued sentimentalists, who, in view of the researches they oppose, and the fatal effects of their opposition, might be fairly described as a crew of well-meaning homicides. The only way of combating this terrible scourge of tuberculosis, and, indeed, all other infectious diseases, is experimental investigation; and the most effectual mode of furthering such investigation, in England, is the establishment of the "Institute of Preventive Medicine," which, I am rejoiced to learn, has, after due consideration, been licensed by the President of the Board of Trade. Whatever my illustrious friend, the late Mr. Carlyle, may have said to the contrary, the English public, in its relation to the question now before us, are *not* "mostly fools;" and if scientific men only exhibit the courage and industry of their opponents, they will make clear to that public the beneficence of their aims, and the fatal delusions to which a narrow and perverted view of a great question has committed the anti-vivisectionist.

[While correcting the proof sheets of this article, the *Times* of August 11 reached my hands. Its leader on the Congress of Hygiene and Demography contains the following words, to which I heartily subscribe: "*The most pressing work of sanitary reformers is not now so much to legislate as to educate; to make the mass of the people, in some degree, participators in the knowledge of the causes of disease which is possessed by men of science.*"]—*Fortnightly Review.*

BREEDING AND REARING OF PUPPIES.

One of the most important parts of the dog owner's duties is that relative to the rearing of the puppies that may be born in his kennel. The late Charles Darwin in his Descent of Man said: "It is surprising how soon a want of care, or care wrongly directed, leads to the degeneracy of a domestic race!" And breeders of all kinds of live stock know this to be perfectly true. No amount of care and attention will turn an ill-bred and badly formed animal into a good one, and years of anxiety, trouble and expense go for nothing if proper regard is not paid to the selection of the stock from which to breed! We will admit that many good-looking dogs, including some that have won no end of prizes, have been bred in a haphazard or happy-go-lucky fashion, but it would be most injudicious to breed from such sires or dams, for sooner or later the breeder would meet with severe disappointment, and probably throw up the whole thing in disgust, regarding the business as a lottery. That it is not a lottery is amply proved by the fact of there being so many specimens at the present day the result of careful breeding from pedigree stock. We desire, therefore, to impress upon the minds of all breeders the necessity of exercising the greatest care in the selection of stock and the importance of adhering to one type.

Before commencing operations the breeder must make up his mind what he desires to obtain, but in the case of a novice we should suggest his endeavoring to secure the help of some one in his neighborhood who has had experience in breeding. It is impossible to put down on paper with sufficient clearness rules to meet every individual case. So much depends upon the animal to be bred from, that we suggest the course already mentioned in preference to any other. Usually old breeders are most ready to help the new beginner. But it is very desirable that the owner of the dog should know as much as he can, and therefore he should study the uses of the various breeds which have been brought into existence; so that in the decision as to any variety, he may know which is best suited to his purpose. In selecting a stud dog, it is advisable to choose one that conforms to the orthodox standard, and whose pedigree is pure. Even though the well-bred dog fails to impress his own likeness upon his stock, it is more or less probable that some of the puppies will "throw" back to a well-bred ancestor of first-class proportions, while in the case of a badly bred sire the litter will be chiefly distinguished for its variety in type, temper, etc.

The vexed question of in-breeding has been fought over and over again, and like many other subjects has its champions both for and against. But from the most reliable evidence before us, there seems to be little doubt that in-breeding may be permitted to a limited extent, and when not carried too far is useful in maintaining certain features. When adopted, it is much better to put father to daughter, and mother to son, than brother to sister. But the greatest care is needed in the adoption of this system, for when carried too far it not only stops the growth of the progeny but weakens their intelligence and constitutions. It is a general axiom that once in and twice out is a safe rule for in-breeding.

Very much depends on the selection of the stud dog, and too much attention cannot be paid to the state of his health. A delicate or unhealthy dog is more likely than not to transmit some of his defects to his offspring, the consequence of which will be that there will be greater difficulty in rearing the puppies, and they will probably be of less value when they reach maturity, if ever they do so. The diet of a stud dog must be good and liberal, and he should be exercised every morning and evening, either by being taken out for a walk or having a good scamper round his playground. A plunge into cold water helps wonderfully in keeping a stud dog in vigorous condition, and in warm weather this bath can be allowed daily. Those who wish to secure the services of a stud dog other than their own, are advised to see it for themselves and then judge from its condition and appearance whether it is likely to suit or is in a good state of health.

An equal amount of attention should be paid in the selection of the female as of the male. And it must be borne in mind that the mothers should be specially strong in those points wherein the sire is deficient, so that the two may "nick" well together. It is a generally accepted fact in breeding that the sire gives the outward formation, while the dam controls what may be called the internal qualities, such as temperament. Both in the case of sire and dam, the animals should be well grown before they are used for breeding, and it is inadvisable to use either until they have reached a year and a half old. Some young bitches show a disposition to breed very early, and when this is the case precautions will have to be taken in order to prevent a *mesalliance*. When the proper time has come, and it is evident that the bitch is in season, arrangements should at once be made for the service of the stud dog. The period of heat generally lasts about three weeks, and the best time to use the dog is after a fortnight has expired, when a discharge which takes place about that time ceases.

When it is clear that the bitch is with pups she should be very well exercised up to about the sixth week, after which, though daily exercise is necessary, it must be gentle, care being taken to see that she has no violent jumping, straining or galloping. It is also a good plan to lead her when out for a walk during the last week of her pregnancy. If these directions be carried out a healthy bitch will need no medicine. During all this time her food must be regulated, and care taken that she is neither too fat nor allowed to get too thin, as both states of the body are equally dangerous. The happy mean must be attained, and this will be most compatible with a high state of health. In order to know whether the bitch is in this condition the ribs may be taken as a guide. If they can be felt but are not evident to the eye, she may be regarded as in a proper state of body. The food should be liberal, and consist chiefly of slops, such as broth, gravy, milk and bread, with scraps from the table and vegetables. The quantity of meat should be very limited, though if she has always been used to it a small portion may

still be given, as in such cases it would be unwise to withhold it altogether.

A week or ten days before her time is up, the bitch will begin to grow restless, looking out for a quiet corner where she may make herself comfortable and be at home during her coming trouble. It is best to give her a quiet place where she will be alone, and free from interference by other dogs. All that will be necessary in her new abode is a flat, smooth piece of board raised a few inches off the floor, over which may be nailed a piece of old carpet and some straw over all. The board, which may be thirty to forty inches wide, according to the breed of dog, should have a flap nailed round it so that the whelps may not roll or tumble off, as they would otherwise be very apt to do. The carpet is needed so that the little strangers may hold themselves firmly, by their claws, while suckling. While whelping is going on the chief thing is to secure perfect quiet for the bitch, who should be disturbed as little as possible. If she is in good health and her time of labor is not unduly prolonged, the best way is to leave her alone, for some bitches are very suspicious and easily made angry at such a time. No feed should be given during the process, but there should be some water within reach. After the labor is entirely over some milk-warm gruel should be given the bitch, who should have this every two or three hours for the first three days. It is both strengthening and soothing, and can be made with either milk or water. Half milk and half water is a very good mixture. She will also relish a little beef tea or gravy after the first few dishes of gruel.

It has been already stated that at the time of the bitch giving birth to her pups she should not be interfered with, for many bitches are very suspicious and easily made angry at such a time. It was also stated that she would require no food, only needing a dish of water so that she can quench her thirst now and again. The milk-warm gruel should be the bitch's food for the first three or four days. It is both strengthening and soothing, and can be made with milk and water—half of each is very good. She will also relish some beef tea or gravy after the first few basins of gruel. The mother should be coaxed to leave her bench for a few minutes twice a day. This will stretch her legs, and also do good in that it will cause the milk to flow much more freely. Too many pups must not be left with the mother, for in addition to their being too great a strain upon her, it will be impossible that they can all be reared, the sickly ones very soon reducing the number by their death, or what is much worse, all the litter being sickly and delicate. Five or six are sufficient for a moderate sized bitch to bring up successfully, and ten for a larger one. Should there be more than these in the litter, and the breeder does not wish to destroy them, they must be taken over by a foster mother, which useful animal can usually be secured by advertising and for a reasonable sum. Many breeders, however, prefer to pick out the best of the litter and let the bitch bring these up, destroying the others rather than trust them to a foster mother or to bringing them up by hand.

For the first ten days or a fortnight the mother will give all the nourishment to her family that is necessary, but when the longer of these two periods has expired they should be taught to look after themselves a little. Some milk may be placed in saucer, and they be enticed to drink. It is often necessary to teach them to do this, and one of the best ways is to dip the finger in milk and then insert it into the mouth of the pup, at the same time drawing their mouths down into the saucer. They begin to suck the finger and learn from the result arrived at what it is desired to teach them. When once their eyes are opened, which is about the ninth day after birth, it is astonishing how soon they begin to crawl about their nest, and when they do this a very rapid increase of strength and size takes place. About a week after they begin to take the milk, they will eat and relish bread and gravy, and bread and milk. The latter, however, has been objected to as liable to sour on their stomachs, and if cow's milk, to breed worms. Considerable discussion has taken place on this point, and there appears to be quite an amount of force in the objection to milk. During all this time the mother must be kept on nourishing food, and have gentle exercise once or twice a day, so that she may not be subject to the constant persecution of the whelps, now getting very strong.

When about five weeks old the weaning may be begun. This must be done gradually, as the puppies will thus suffer less then if at once deprived of their natural sustenance. A good method is to remove the bitch for an hour or two during the warmest part of the day, gradually lengthening her absence until she is beside them only at night. This is a very critical period in the lives of the puppies, as they are subjected to an entire change in their mode of living. Sometimes, although the food is within a few inches of them, it does not appear to enter into the head of puppydom to hunt about for a feed, until some one more bold than the rest breaks away and begins to navigate the new world on his own account. He is soon brought face to face with his food, which it is needless to say he goes at without a moment's hesitation, the others very soon learning to follow his example.

Puppies suffer greatly from worms, which are the cause of very many of the diseases to which they are subject, and as soon as they are removed from the mother means should be taken to rid them of these pests. For this purpose there is nothing better than Spratt's worm powders, given in the doses recommended on the packets. When the pups are fairly weaned, their food should consist of crushed dog biscuits, Scotch oatmeal porridge, gravy, and a little chopped meat and vegetables. They should be fed several times a day, but as soon as they are satisfied the food should all be taken away, as nothing disgusts them more than to see the food standing about, besides which it gets dirty and sour, and if then partaken of, evil results will certainly follow. The whelps should be kept in a warm and dry place where there is no draught, and be permitted to scamper about in a dry yard, or they will not grow as they should do. If particular care be paid to food and exercise, and they are kept clean, there will be less danger of distemper, or should that disease attack them it will probably be of a mild character.

The quantity of food required by a growing puppy is from the twelfth to the twentieth part of the weight of its body, varying of course with the rapidity of its growth and the breed. Thus a twelve pound dog would require between half a pound and a pound of food per diem, and a dog three times that weight from two pounds to three pounds. When the dogs are fully grown they will not often, except when hardly worked, need more than the smaller of the weights given—namely, one-twentieth of their own weight, which may be taken as the average weight of fairly substantial food for dogs with but a moderate amount of exercise. Dog feeding is a simple thing nowadays, and as soon as the puppies are well grown there is nothing better than Spratt's dog cakes, which seem to be obtainable everywhere, and are easily prepared—no light consideration in a small kennel.

An all-important matter in the rearing of puppies is exercise, which must on no account be neglected, or all the labor, care and expense will be thrown away, for without exercise they cannot possibly thrive. Those who are fortunate enough to live in the country can generally secure any amount of exercise for their dogs in meadows, or on common lands, where they can scamper about to their hearts' content without annoying any one. And there can be no question but that it is much easier to rear dogs in the country than in towns, the conditions in every way being more favorable. Those who live in towns are much more restricted in their opportunities of time for exercising their dogs, for to nervous people nothing is more annoying than to meet a troop of dogs on a busy street. The best time to exercise dogs in towns is in the morning before any people are astir, or in the evening before the dogs go to rest. In all cases, the dogs, whether in town or country, should be exercised in the morning before they are fed, as after feeding they should be allowed to rest.

A necessary provision for the rearing of puppies is that sufficient room should be provided, so that the youngsters may romp about their yard. A large bone, too large for them to swallow, will often be the means of causing them to exercise themselves, and will afford them hours of amusement. A portion of the playground should be covered over, as it is very bad for any dog to be exposed to the heat of the sun, and nothing will so soon throw him out of order as lying about in the heat. If these few simple directions are carried out, the breeding and rearing of dogs will offer no great difficulties to any one either in town or country, but be a source of very great pleasure.—*Stephen Beale, in the Country Gentleman.*

RICE CLEANING IN CHINA.

THE United States consul at Hong Kong says that all the rice received there is unclean, with the exception of that brought from China, the average of paddy being about 20 per cent. It is prepared for market at Hong Kong, with the exception of that shipped to Canton, which, owing to the cheapness of labor in comparison with Hong Kong, is cleaned there. The process of cleaning is slow, and the labor most harassing. It is first run through hand sieves to separate the paddy from the grain. The paddy is first run through a machine made of wood, shaped not unlike a set of millstones, both sawn from a log about three feet in diameter. Into the face of the under block, and flush with it, is let a circular stone of a diameter to leave a five-inch rim of wood. This stone is opposed to an opening or eye in the upper block of a like diameter, into which is fitted a perforated board. The opposing surfaces of the two blocks are cut into grooves three-eighths of an inch wide, one-fourth of an inch in depth, and about the same distance apart, the intervening ridges of wood being carefully trimmed about every three hours, in order to be kept sufficiently sharp.

The upper block is dragged round by means of a hook at the end of a wooden handle fastened to a staple driven into the rim, a single workman turning it and, at the same time, feeding the machine by throwing the paddy with a wooden paddle into the eye, from which it is distributed outward by the centrifugal force. This breaks and loosens the husk from the kernel, after which it is run through a fanning mill, constructed with about the same regard to mechanics as the rudimentary machines described above. The grain, divested of husk, is now ready for the scouring process, which is done in stone mortars, holding about a bushel. These are set into stonework level with the floor, at an angle of about 30 degrees, twenty or more being distributed about, according to the size and shape of the room. A wooden framework is built over the mortars in such a way that a stone pestle, weighing twenty-five pounds, fixed to a beam pressing over a fulcrum, is rapidly dropped upon the grain. This is accomplished by a workman, who steps quickly upon the short end of the lever, and as quickly removes his weight when the pestle has been elevated to the highest point.

The number of strokes considered necessary for this part of the process varies with the kind of rice, from two to four thousand. Ashes made from rice husks, to the amount of one-fourth of a pound, are added to each mortar of grain at the beginning of the pounding, and a second time when the pounding is half finished, the rice by this time having become quite warm. It is now taken from the mortar to be sifted, after which it is replaced for foot-scouring, ashes being added for the third time. A bare-footed workman, supported from falling by reclining in a kind of swing, treads in the mortar, which causes a rapid movement of the rice. This is continued for from thirty to forty minutes, when it is taken out and sifted, and is now ready for market. A part of the dust, composed of ashes and disintegrated rice, resulting from the scouring, is combined with 10 per cent. of salt and used in preserving vegetables. What remains is given to swine. Consul Simon says that, crude as these appliances are, they accomplish the work with the least breaking and crushing of the grain possible, and no doubt comprise most of the principles upon which rice-cleaning machinery is or should be constructed. The rice merchants in Hong Kong say that owing to the cheapness of labor, improved machinery propelled by steam, such as is in use in Bangkok and Saigon, would not be profitable in Hong Kong, and would not be permitted in China, where a vast number of people find, in rice cleaning, their only means of earning a living.

THE CHINESE CUSTOM HOUSE.

IT was Sir Robert Hart's "At Home" day, for every Wednesday afternoon the Inspector General of Chinese Customs at Pekin receives his friends in the garden surrounding his house, where they can enjoy lawn tennis and dancing. This is the only day of the week on which he is visible, except on actual business. He invited me to stay to dinner, and I was glad of the chance of a quiet talk with him. Sir Robert, who was born in Belfast in 1834, joined her Majesty's Consular Service in Hong Kong in 1854; and the following is his own account of his career:

"After I had been in the Consular Service five years, I was invited to join the Chinese Customs. This was shortly after Lord Elgin's treaty, when certain ports were to be opened to Europeans. Something inspired me to accept the offer; one thing led to another, and in 1861 I was made Acting Inspector General, in the place of Mr. Lay, who was going home on leave for two years. A few months after his return to China he was compelled to resign, and I was appointed Inspector General in his stead. So, in four years I had risen to the highest post in the service. In those days the position was not nearly so important as it is now, for the Chinese Customs Service was in its infancy. It has since grown to such huge dimensions that the work it entails is something incredible. In 1861 there were only three ports open to Europeans, whereas there are now thirty; the ramifications of the system extend as far south as Tonkin, and in the north to Corea. Over 700 Europeans and 3,000 Chinamen, of all classes, are employed in the land service alone. The entire coast line is guarded by twenty armed cruisers of the very latest types, built in England, most of them by Armstrong. These cruisers are commanded by Europeans and manned by Chinese. There is, besides, quite a flotilla of armed steam launches used in the various harbors. The lighthouses along the coast are also under my jurisdiction. Each port has its European commissioner, who has acting under him a Chinese official and staff of assistants, European and otherwise."

"How do you admit Europeans into the service?" I asked. "Have you a competitive examination, or are special qualifications necessary?"

"Well, it is very seldom there is a vacancy," replied Sir Robert, "but when there is, there are so many candidates on the waiting list that my agent in London has a sort of examination held; but, of course, a man with some knowledge, however slight, of Chinese has the best chance of getting on."

"But how is all this supported?" I naturally asked, though aware that the Chinese Government got a splendid revenue out of the Customs Service.

"The Chinese Government," replied Sir Robert, "allows about £400,000 a year for the support of the service. This is absolutely under my control; also the appointment or dismissal of all officials. The Chinese Customs are assuming bigger proportions every year, and are an ever-increasing source of revenue to the State. The great mistake that foreigners make with regard to China is to imagine that she is in want of extraneous pecuniary assistance—that she is bordering on a state of insolvency. Nothing could be more erroneous; it is rather the other way. If the Chinese moneyed men only trusted their own government a little more, China would undoubtedly soon be in the position of being able to lend money to other countries. Putting this aside, China is not trying, nor has she ever been trying, to borrow money, though many German, French, and other syndicates have been doing their utmost to lend her some."

I could not help remarking that this was a very enviable position for a country to be in.

"Besides," continued Sir Robert, "the system of such loans is contrary to Chinese ideas; for a Chinaman prefers a short loan at a high rate of interest to a long one at a low rate. I have been much amused, knowing what I do, to hear of agents of syndicates stopping in Pekin for months at a time on the chance of floating a loan. In several cases, in their anxiety to do business, they were on the point of doing so with the wrong people. After all, the Chinamen are no better than they ought to be; and as it takes so little to make the average European believe that every well dressed Celestial is an official mandarin, they often took advantage of this simplicity of the Western barbarian. There were some extraordinary cases, a few years ago, of people being introduced to one of these agents as the Grand Chamberlain of the Court, or some other high dignitary, empowered to negotiate a loan. They were absolutely nothing of the sort, but were perhaps connected with officialism in the remotest and obscurest way. In some instances, however, though not what they pretended to be, the agents were actually connected with the big officials. This was proved by the fact of the Government, though not recognizing the loan thus obtained officially, still assuming to a certain extent the responsibility of it, as it had been used partially for official purposes. Very little, however, has transpired of these curious transactions.

"As it has been with loans, so it is with railways. Undoubtedly China will one day have her railways, but though she has for years past been pestered with offers by foreign capitalists to help her start them, so far the reply has always been that when the time comes the engineers, the capital, all that is needful, will be found by China—a strong hint, which has not, however, been taken, that no foreigners need apply. Of one thing I feel convinced," continued Sir Robert, "that China, though certainly very many years behind hand, is undoubtedly going ahead—advancing slowly, it is true, but still advancing, and every step she takes forward is a certain one. In spite of sarcasm and adverse criticism she adheres to her slow, steady pace, and, so far, has never receded a single step. As compared with Japan, she reminds me always of the old adage of the hare and the tortoise."

Having finished our coffee we rose from the table and had a stroll through the suite of rooms in which Sir Robert dwells in solitary grandeur. There was a striking absence of the "curios" which one would have expected to find in the quarters of a man who had passed so many years in the "far East." Beyond his work Sir Robert had evidently but few hobbies. In one corner of the drawing room was a large table covered with the Christmas cards which my host re-

GLACIAL PHOSPHORIC ACID.

Sample	Origin	Form	Free HPO_3	Combined HPO_3	Equal to $-PO_3$	Total HPO_3	Total by Uranium	Total Base	Ammonium	Sodium	Equal to $\left.\begin{matrix}Na_2\\H\end{matrix}\right\} PO_4 + 12H_2O$	Water	Silicia	Arsenic	Total
A	Made by ammonia process	Lump	48·00	43·52	42·98	91·52	91·84	8·05	8·05	None	—	Trace	0·54	Trace	99·57
B	English	,,	52·80	40·00	39·50	92·80	93·14	7·82	6·48	1·34	10·44	,,	—	0·08	100·20
C	,,	,,	46·08	39·36	38·87	85·44	85·40	9·79	0·07	9·72	75·63	5·60	—	Trace	100·34
D	German	,,	31·68	52·80	52·14	84·48	84·98	14·09	0·05	14·04	109·30	2·40	—	,,	100·31
E	,,	Sticks	36·48	47·36	46·77	83·84	83·70	13·49	0·06	13·43	104·48	3·25	—	,,	100·00
F	European*	Lump	42·21	37·89	37·41	80·10	80·41	10·20	None	10·20	79·30	10·10	—	,,	99·92
G	Experimental	,,	44·16	46·72	46·14	90·88	90·65	10·10	4·87	5·23	40·67	Trace	—	,,	100·40
H	Experimental from microcosmic salt	,,	None	—	—	—	78·12	22·50	—	22·50	—	—	—	—	99·70

* This is the sample referred to as sent from America, and being of European origin.

ceived last year from his many friends all over the world. Sir Robert's office—or, rather, his "den," as he called it—was very characteristic of the man, for here he spends the greater part of his day. He never sits down to write, but always stands at the tall desk in the center of the room. "The air of Pekin," he added with a smile, "has a very somniferous effect, and I feel sure I should instantly fall asleep if I were to sit down to my work of an afternoon."

Leading out of the "den" was a room which Sir Robert told me he uses as his audience chamber, where he receives all Chinese officials. The place was furnished in a sort of semi-Chinese fashion, with the indispensable raised platform for sitting, and the usual small table. I remarked that I had often heard how difficult foreigners usually found it to get on with the Chinese mandarins of high rank. "Well," replied Sir Robert, "owing to the favor of the Emperor, there are few with whom I am brought in contact who hold a higher rank than my own; for I am the happy possessor of almost all the distinctions, a Red Button of the First Class, a Peacock's Feather, and the First Class of the Second Division of the Double Dragon. But the honor recently bestowed upon me is the highest that it is possible to confer on even a most distinguished Chinese subject; my family was ennobled by Imperial decree, to three generations back—that is to say, 'Ancestral rank of the first class of the first order, for three generations, with letters patent.' The value of this decree may be estimated from the fact that at the same time the Emperor ennobled his own grandmother in the like fashion, she having been an inferior wife of the Emperor Taou Kwang, in whose reign took place the first opium war." Sir Robert is also a Knight Grand Cross of St. Michael and St. George, and a Grand Officer of the Legion of Honor.—*Julius M. Price, Illustrated London News.*

GLACIAL PHOSPHORIC ACID.

By JOHN HODGKIN, F.L.S., F.I.C., F.C.S.

A SAMPLE of glacial phosphoric acid was received from America, which was stated to be the quality usually sold in the special market whence it came [United States]; it was imported from Europe. On analyzing it a large quantity of soda was found to be present; it was, therefore, a matter of some interest to examine a few samples, English and foreign, to see what was being sold.

Two English and two German samples were examined. For purposes of comparison a small batch of glacial phosphoric acid was made by the regulation method given in the text books, namely, by calcining phosphate of ammonia. This was analyzed, and the results of the analyses of the other samples were compared with it. The method devised for analysis of the free and combined metaphosphates was a new one, founded upon Thompson's observations on indicators, based upon the facts that dihydrosodic phosphate is neutral to methyl orange, but acid to phenolphthalein, and that hydrodisodic phosphate is neutral to the latter indicator. By this means we are enabled to estimate the *free* and *combined* phosphates. The sample of glacial acid, consisting chiefly of metaphosphates, is boiled, preferably with a known quantity of standard sulphuric acid, for about ten minutes, to convert the metaphosphate into orthophosphate. This is essential, since, though methyl orange reacts indentically with metaphosphoric and authophosphoric acids, with the former acid phenolphthalein gives no definite results. The sample is then titrated with normal soda solution, methyl orange being the indicator. The number of c. c. used after subtracting the equivalent of the standard acid used for conversion into orthophosphate represents the *free* metaphosphoric acid—1 c. c. NaHO solution being equal to 0·08 HPO_3. The reaction is:

$$H_3PO_4 + NaHO = NaH_2PO_4 + H_2O$$

This same solution is then titrated afresh with normal soda solution, using one drop of alcoholic solution of phenolphthalein as an indicator. The number of c. c. used represents the free and combined or total acids. To calculate results, subtract twice the number of c. c. used in the methyl orange determination, and the balance represents the original combined metaphosphate. The reason for subtracting twice the number of c. c. originally noted is that it takes twice the quantity of normal soda to form the salt Na_2HPO_4, which is neutral to phenolphthalein. The reaction is:

$$H_3PO_4 + 2\ NaHO = Na_2HPO_4 + 2H_2O$$

This is an accurate method, and was carefully checked by the uranium process.

The sodium was estimated by Bettendorff's process (*Zeitschrift fur Analytische Chemie*, 1888, p. 24), which consists in placing a few grammes of the glacial acid in a known quantity of fuming hydrochloric acid—sp. gr. 1·190—allowing to stand twenty-four hours, filtering through spongy platinum, washing with fuming acid, igniting and weighing, allowing for the solubility of the NaCl in the fuming acid (1 part NaCl = 1,348 parts HCl, 1·190). The ammonia was estimated by distilling with an excess of soda into decinormal acid, and titrating with methyl orange.

The results of the analysis of sample A, namely, that prepared by calcining phosphate of ammonia, showed that it is not possible to drive off all the ammonium, about 8 per cent. remaining. This requires a large percentage of metaphosphoric acid for neutralization. The *free* acid is 48 per cent.; combined PO_3, 42·98 per cent. A small percentage of silica was found, which was contained in the phosphoric acid originally employed to make the phosphate of ammonia. Sample B, of English make, was the best in comparison, but contained soda, as well as ammonia; the free acid was 52·8 per cent. The sample contained appreciable quantities of arsenic. Sample C is also English, and contains large quantities of soda; in fact, every pound weight of this acid contained soda equal to ¾ lb. weight of hydrodisodic phosphate. D and E are both German samples, and contain soda equal to over 100 per cent. of phosphate. F is the American sample referred to, and somewhat resembles C in its composition. G is an experimental sample, made by deliberately adulterating phosphate of ammonia with phosphate of soda, and calcining. It contains, curiously enough, *ammonia*, whereas in sample H, made by calcining microcosmic salt, HNH_4NaPO_4, all the ammonia has been expelled.

To sum up the results, the use of soda is discouraged, as it leads to extensive adulteration. A good article, hard enough for all purposes, can be made by adhering to the regulation ammonia method. There is no advantage in having a very hard preparation if the quality is to suffer so enormously.

The author, in concluding, advised pharmacists to use Bettendorff's test qualitatively; to unhesitatingly reject samples which show soda to be present; to insist upon the article being soda free, and with no other base than ammonia present; and, in order to insure the percentage of free acid being kept up, to use the simple titration method with methyl orange for free acidity.—*Chem. Tr. Journal.*

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.